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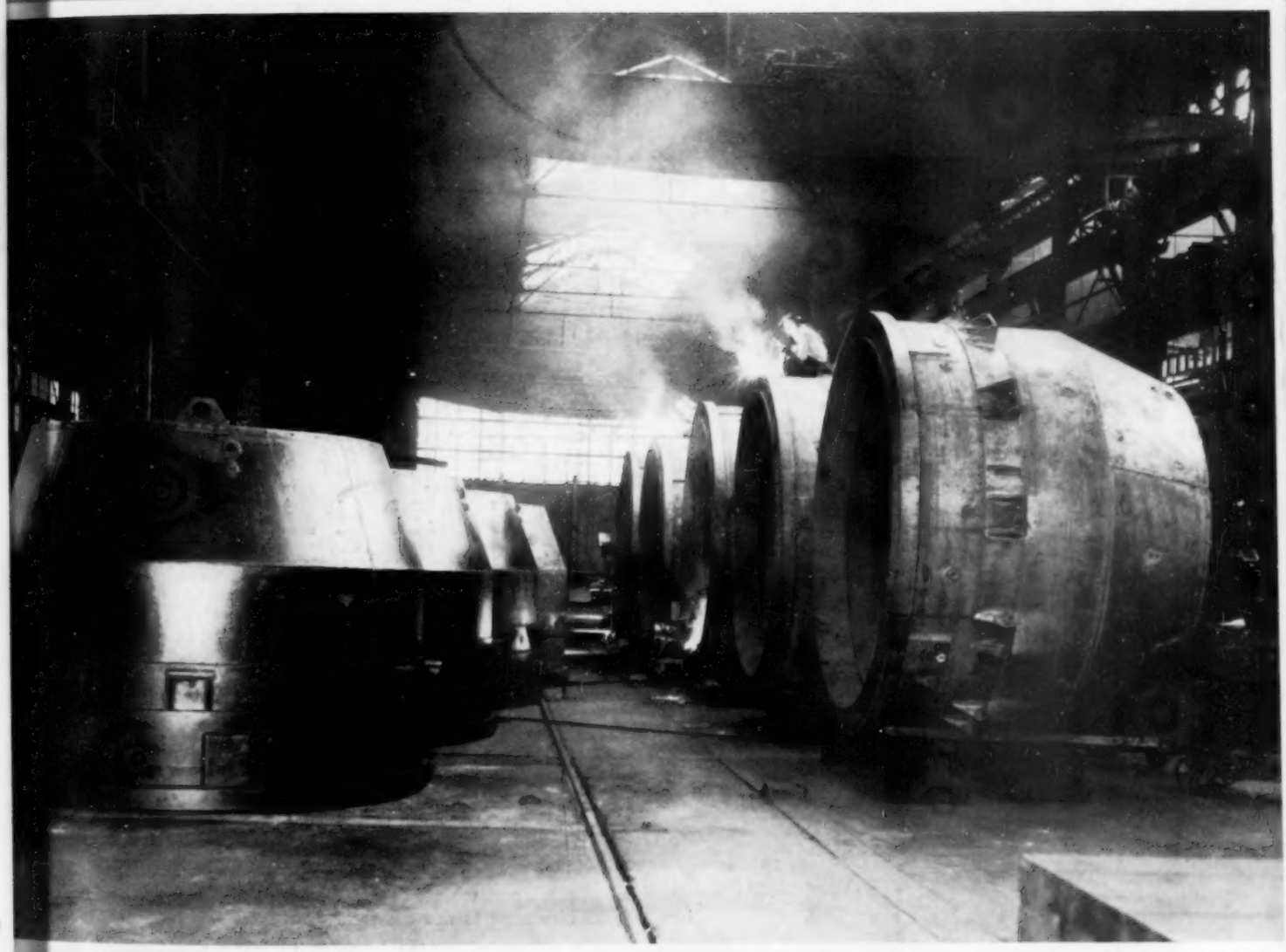
The WELDING Journal



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Welding Journal
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Welding Metallurgy

VOLUME 2

By O. H. HENRY and G. E. CLAUSSEN

A series of lectures prepared for presentation in a fundamental course of metallurgy and metallography at Polytechnic Institute of Brooklyn under the joint auspices of the Institute and the New York Section of the AMERICAN WELDING SOCIETY. To be published serially in The Welding Journal. The lectures are reproduced in attractive booklet form, copiously illustrated—357 pages—with imitation black leather covers. Volume 1 consists of the first series of 10 lectures given by the New York Section in cooperation with the Polytechnic Institute of Brooklyn last year. Volume 2 includes the series of lectures to be given this year. The price of the book containing both volumes is $1.50 per copy. Special prices can be arranged for quantity lots of 50 or more.

INTRODUCTION

Intelligent application of welding has been found to require a knowledge of the important characteristics of steels from the welding standpoint and of the effect of welding upon the steels. These subjects are Welding Metallurgy. The previous ten lectures, presented as last year's course, set forth the elementary facts and, particularly, the basic principles. The following eight lectures cover new ground and require of the student familiarity with the previous lectures.

Part I emphasizes the large number of factors that control the distribution of temperature during welding. Neglect of any single factor is likely to cause trouble. In Part II there is a description of the method by which the proper composition of a steel can be determined knowing the rates of cooling during welding. The precise meaning of brittleness and the principal conditions under which a metal can be made to exhibit brittleness are dealt with in Part III, while in Part IV the origin of shrinkage, which may cause cracks, is explained. The metallurgy of the weld melt is outlined in Part V, which points out the basic factors that control the purity of the weld metal and its behavior during deposition. Parts VI and VII describing a number of steels that the welder frequently meets are followed by a discussion of the avoidance of difficulties through preheating and stress relief (Part VIII).

To imagine that every subject of welding metallurgy is discussed in the lectures would be ridiculous. Many attractive subjects, such as non-ferrous welding, have been scarcely mentioned in the effort to compress essential facts and principles into as few pages as possible. Ten years hence many of the explanations in these pages will have become obsolete and inadequate. At the present time, however, the explanations and discussions are useful guides in recognizing trouble and in devising remedies.

ACKNOWLEDGMENT

It is a pleasure for the authors to record their indebtedness to the members of the Lecture Course Committee who outlined the scope of the lectures as a whole, and to Mr. W. Spraragen who read the manuscript and suggested important additions to numerous vital passages.

Part I—Heat and Time in Welding

Before we can be said to have control over the metal in the weld and the adjacent heat-affected zone during welding, we must know the temperature reached by every part of the joint and the time at those temperatures. Welding metallurgy can lay claim to being a branch of metallurgy only in consideration of the unusual combinations of temperature and time that must be dealt with in welding. The temperature changes during welding are generally wider and more abrupt than in any other metallurgical process. Furthermore, only very limited recourse can be had to the familiar metallurgical operations of working and controlled heat treatment upon which the metallurgist ordinarily relies to place his products in their most advantageous position. Nevertheless, a number of astonishing and unpredictable facts have emerged from the study of welds, such as the fine grain size of mild steel weld metal, that have forced us to adopt new conceptions applicable only to welding.

As the first step toward a more complete understanding of welding metallurgy, Part I sets forth the main facts about the temperature during welding. In Vol. I the

main emphasis was placed upon the maximum temperatures reached at all parts of the joint during welding. The present Part I emphasizes the rates of cooling at all parts of the joint, and shows that cooling rates are determined fundamentally by the heat input (a treacherous term), the mass of the base metal in contact with the weld metal, and the initial temperature of the base metal. Cooling rates during welding will be the thread that will be woven back and forth during the four succeeding parts.

Heat has the effect of raising the temperature. To raise the temperature of 1 lb. of water 1° F. requires 1 Btu. or 252 calories. In making a spot weld in heavy steel plates we may raise 1 lb. of steel to its melting point (2700° F.) almost instantaneously. The approximate amount of heat required to melt 1 lb. of steel is 1 lb. × 2700° × 0.1 = 270 Btu. or 70,000 calories (specific heat of steel = 0.1; that is, to raise the temperature of 1 lb. of steel 1° F. requires only 0.1 Btu.). To secure 70,000 calories we need its equivalent 300,000 watt seconds, which is supplied by 10,000 amp. for 10 seconds at 3 volts across the plates to be spot-welded.

In practice we find that we need more heat than we calculated to secure the right amount of weld metal. The reason is that once the temperature is raised at one spot in a plate, the temperature rises at all regions in the vicinity according to the physical law of heat conduction. Therefore, the heat of welding must be sufficient not only to melt the metal required for welding, but to raise the temperature in the vicinity of the weld to the extent required by the law of heat conduction.

In resistance welding the heat for welding is generated within the metal itself. In torch welding, the heat is generated in the flame, the high-temperature molecules of which impart their thermal energy to the metal. Thermal energy arises from the fact that all matter is in chaotic motion. The speed of motion of the individual particles (molecules) of a gas rises with rise in temperature. It happens that energy is the product of mass times square of speed and, furthermore, that the kinetic energy of each molecule is directly proportional to the temperature. The energy of the gas, that is, of the molecules, in a high-temperature welding flame consequently is very high, and is increased by the rotation of the molecules themselves, which adds to the energy of translational motion.

When the flame surrounds the metal, the atoms at the surface of the metal attempt to attain the temperature of the flame, thus establishing equilibrium. As the thermal energy which is the measure of temperature, increases among the surface atoms, the atoms deeper below the surface attempt to attain the temperature of the surface atoms and their temperature likewise rises. The law governing the transmission of the energy to change the energy of the atoms is the law of heat conduction.

In arc welding, the metal to be welded is one pole of the arc; the electrode is the other pole. Thus, the metal to be welded participates in the production of heat, which is not so in torch welding. In arc welding the metal is not the sole source of heat, as it is in resistance welding. The heat developed by the arc is approximately: arc voltage × arc current × time the arc burns. For instance, a covered electrode arc at 35 volts, 150 amp., liberates 150 × 35 = 5250 watts every second. In one second the arc therefore develops 1250 calories or 5 Btu. (equivalent to melting 0.02 lb. of steel in a second). Some of the heat developed by the arc is lost to the air, as the welder behind his shield will realize. Tests have shown that about 1/4 of the heat developed by the arc is lost to the air (including vaporization of steel) and the electrode. The remaining 3/4 of the heat acts to raise the temperature of the parts to be welded. A similar proportion of the heat from a welding torch doubtless is lost to the air. The heat liberated by a welding flame is the product of volume of combustible gas delivered by the torch and the heat of combustion of a unit volume (cu. ft.) of the gas.

Having discussed the origin of welding heat, we are in a position to discover what effect the heat exerts on the temperature of the parts to be welded, and also what becomes of the heat in the metal. In Fig. 1 a flame is playing on a metal surface, and we are measuring the temperature at a number of points (line *AB*) just beneath the surface. If there were no such thing as heat conduction, or if the flame were able to bring the surface under the tip of the inner cone instantaneously to the fusion temperature, our pyrometers connected to points along *AB* would indicate the temperatures shown by the full lines in the lower part of Fig. 1.

Actually, however, metals are good heat conductors; the atoms in the metal pass the heat along rapidly to their neighbors. Besides, the heat to melt the metal cannot be supplied instantaneously by the flame. Heat is a product of amperes, volts and, all-important, time, as we have seen. For these reasons our pyrometer readings along *AB* will take the form shown by the dotted line in Fig. 1. The dotted curve takes account of time and heat conduction, whose effects were neglected in the full lines. Curves of the type shown in Fig. 1 are called temperature-distribution curves.

In torch and arc welding we can assume for the moment that a point on the scarves receives little heat until the arc or torch is played upon it. As soon as the base metal has been raised to the proper temperature, and the filler metal, if any, has been deposited, the arc or torch is moved on. We are not far from wrong in assuming again that the point in question receives little more heat from the retreating flame. The temperature distribution at the point in question, when the flame is playing upon it, is shown by the straight lines *A* in Fig. 2 (*a*)—the instantaneous-heat-source type of distribution.

When the flame is moved away, heat is conducted from the weld into the plate. So little heat usually is lost

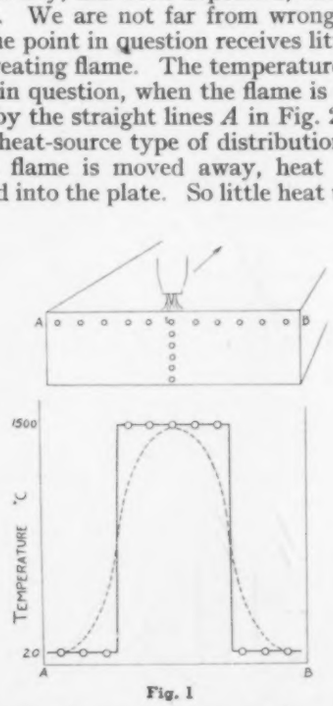

Fig. 1

(Upper) Temperatures are being measured by means of thermocouples at the circles while the arc or torch melts a path across the surface
(Lower) Readings of temperature are recorded along the line of thermocouples *AB*

to the surrounding atmosphere that it can be neglected. Curve *B* shows the temperature distribution a short time (let us say 1 second) after the flame has moved on. The temperature of the weld has fallen while the temperature of the plate near the weld is rising. After another second,

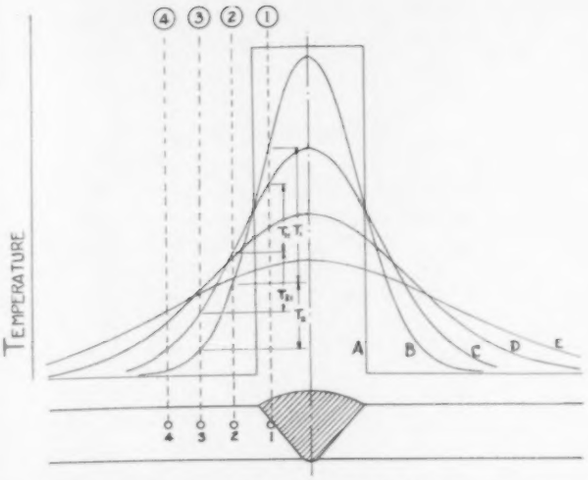

Fig. 2 (*a*)—Temperatures at All Points in the Vicinity of a Weld at Five Different Times. The Curves Were Calculated by Carslaw for an Instantaneous Source of Heat

curve *C*, the weld has cooled still further; the plate is still rising in temperature. Curve *D* represents a later stage; the weld has reached quite a low temperature, and some of the heated zone of the plate (called the heat-affected zone) nearest the weld has also reached the maximum temperature and is cooling. Parts of the plate at a considerable distance from the weld continue to rise in temperature, though only to a small extent.

Eventually, the temperature distribution curve will become horizontal. The temperature at which the distribution becomes horizontal depends on the size of the part we are welding. If the part is thin and narrow, it may be uniformly red hot soon after the flame has passed by. In the majority of welding applications, however, the masses are large and the temperature becomes equalized throughout the part only after it has reached room temperature once more.

TEMPERATURE GRADIENT AND COOLING RATE

At this point we are ready to define temperature gradient—a term we shall meet again in the discussion of shrinkage stresses in welding. Temperature gradient is nothing more than the difference in temperature between two points a stated distance apart. For example, if we are arc welding two steel plates and the temperature 1 inch away from the weld is 100° C., the temperature gradient is approximately 1500 − 100 = 1400° C. per inch. The temperature gradient, however, is by no means constant at any moment during welding. In Fig. 2 (*a*) points 1, 2 and 3 are 1 inch apart, let us say. At the time corresponding to curve *B*, the temperature gradient is T_1°/inch between points 1 and 2. Further, at the time corresponding to curve *C*, the temperature gradient between 1 and 2 has decreased to T_{11}°/inch, but between 2 and 3 the gradient has increased to T_2°/inch. The steeper the temperature distribution curve, the higher is the gradient, which is merely a statement of part of the law of heat conduction.

A more important characteristic of the temperature distribution is the cooling rate. Referring again to Fig. 2 (*a*), we see that the temperature of the center of the weld fell from T_c to T_d in the second between the recording of curves *C* and *D*. The weld therefore cooled at the rate of $T_c - T_d$ degrees per second. During the next second the temperature of the weld did not fall so much; that is, the rate of cooling was retarded.

To understand the basic rules about cooling rate, we draw Fig. 2 (*b*), which represents the same pyrometer readings as in Fig. 2 (*a*). Let us study curve 1, which shows the temperature of point 1 after the flame has brought the point to the molten state, and has passed on. Allowed to cool freely, point 1 at first cools rapidly while the temperature gradient is high. As temperatures become equalized and the temperature gradients become smaller, the temperature falls less rapidly; that is, cooling rates decrease. Between the first and second instants after the flame has passed, the temperature fell, let us say, 500°. The cooling rate therefore was 500° C. per sec. Between the second and third instants the fall was less, only 200°, and the cooling rate therefore was 200° per sec.

We might argue that, since the temperature fell 700° between the first and third instants, the average cooling rate was 350° C. To avoid the complication, we speak of instantaneous and average cooling rates. The average rate is calculated from the temperature drop during a stated time. The instantaneous rate, on the other hand, is computed from the time occupied in cooling through a stated interval of temperature; the smaller the interval the better for welding purposes. For example, the weld metal might fall 1° in 0.001 sec. very shortly after the start of cooling (instantaneous cooling rate = 1000°/sec. at 1500° C.), whereas a minute or so after the flame had passed, the time occupied in falling 1° might be 1 sec. (instantaneous cooling rate = 1°/sec. at, let us say, 300° C.). Average rates are likely to be misleading, whereas, if we know the instantaneous rate of cooling at each temperature during cooling, we cannot ask for more.

Leaving curve 1 of Fig. 2 (*b*), we perceive that the temperature at point 2 very rapidly rises, as heat is conducted to it from the weld metal. The rapid rate of

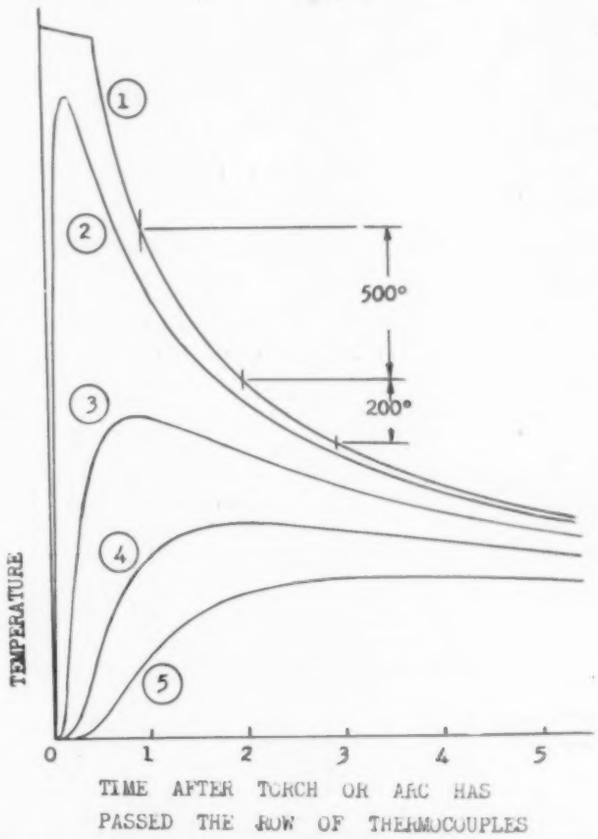

Fig. 2 (*b*)—The Temperatures in (*a*) Are Replotted as a Function of Time for Four Different Distances

heating is a characteristic of nearly all welding processes. The heating rate is most rapid, of course, at the start of a weld when the flame or arc strikes cold metal. Yet it is extremely rare, and only when accompanied by rapid cooling rates and in welding brittle metals, such as white cast iron, that difficulties occur in welding due to too rapid heating. The reason is clear. The instant the average metal is heated to a red heat it loses its rigidity. The metal quickly reaches its maximum temperature, which is a little less than the temperature of the weld metal at that moment. Cooling then sets in, following the same law of heat conduction that is obeyed by the weld metal. Observe, however, that the cooling rate at any temperature always is slower at point 2 than in the weld metal (point 1). Cooling rates become slower the farther we move from the weld, as shown by curves 3 and 4. Other things being equal, the higher the maximum temperature reached by a point in welding, the higher the instantaneous cooling rate will be after cooling has begun.

Before passing from this theoretical discussion to a consideration of temperature distributions and cooling rates in different welds, it should be mentioned that the curves upon which Figs. 2 (*a*) and (*b*) are based were calculated many years before anyone had made temperature measurements of welds during welding. Yet the general theoretical basis of these diagrams has been found to yield results when applied to some types of welded joints, which agree within 5% or so with precise experimental measurements.

TEMPER COLORS

A simple approximate method for comparing the temperature distribution and cooling rates under different welding conditions is to observe the temper colors on the plates after the weld has cooled. The familiar temper colors arise from different thicknesses of iron oxide films on the surface of the steel; the films and their accompanying colors will not form in a non-oxidizing atmosphere, and therefore are not related directly to changes in the structure of the steel.

To permit the temper colors to form, the plates must be sand-blasted before welding. The brown temper color changes to purple at 275–300° C. Consequently, any part of the plate that is in the zone in which the brown temper color is merging into the purple reached a maximum temperature of 275–300° C. during welding. For a given plate thickness the weld in which the brown-purple transition is closest to the edges of the weld has cooled the fastest.

The brown-purple boundary may be about 3 inches from an oxyacetylene weld in 1/2-inch steel plate, but may be only 1 inch from an arc weld in the same plate. Loose statements of this sort are likely to be misleading. For example, if we deposited a series of unusually thin beads in making the gas weld, the temper colors would be closer to the weld than in an arc weld made at high current and slow speed. We must take the rate of heat input into account in stating the type of welding that is being done.

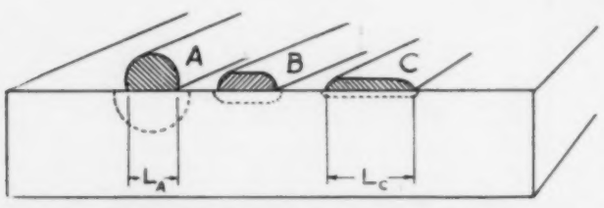

Fig. 3—Three Shapes of Weld Beads Illustrating the Higher Temperature Gradients and Cooling Rates Near *C* Than Near *A*.

Owing to the difference in mass of weld metal at the edge of the bead compared with the center, the cooling rates will vary along L_c

RATE OF HEAT INPUT

The rate of heat input in welding may be expressed in the following way. The arc power in watts (amp. × arc volts) is divided by the speed of travel of the electrode. For example, the rate of heat input of an arc at 30 volts, 200 amp., welding at 6 in. per min. is 1000 watt min. per inch of weld, watt minutes being equivalent to heat. In other words, the arc develops 1000 heat units in making an inch of weld, only 3/4 of the heat reaching the steel. It will make a great deal of difference in temperature distributions and cooling rates, however, if the weld

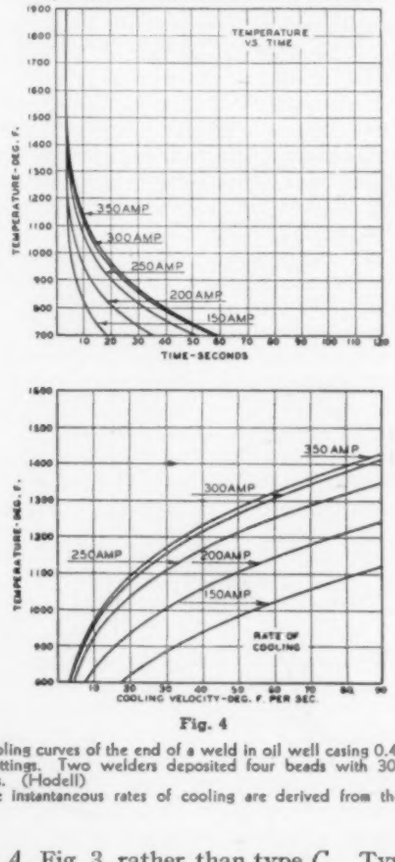

Fig. 4

(Upper) Cooling curves of the end of a weld in oil well casing 0.450-inch wall, at five current settings. Two welders deposited four beads with 30-second interval between beads. (Hodell)

(Lower) The instantaneous rates of cooling are derived from the upper curves. (Hodell)

is of type *A*, Fig. 3, rather than type *C*. Type *A* corresponds with the high bead deposited by a bare electrode, medium arc length. Type *C* corresponds with an exceptionally fluid weld metal from a covered electrode. The brown-purple boundary will be closer to the type *C* weld than to type *A*.

It becomes apparent that to express rate of heat input properly we must base it not only on unit length of weld, but on size (height and width) of bead. If L_a = 1/4 in. and L_b = 1/2 in., the heat inputs in the example become 4000 and 2000 heat units (watt minutes) per inch of weld and per inch of bead. In accordance with our general rule, the higher the rate of heat input, the slower are the cooling rates. Were we to compare a bare electrode with a covered electrode of the same rate of heat input based on length and width of bead, we would be wise to remember that the bead from the covered electrode may be covered with a thick layer of slag. The slag acts as an insulating blanket over the weld, pre-

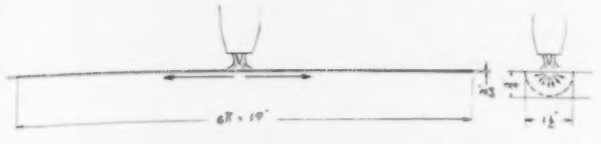

Fig. 5—Assuming Equal Size of Flame and No Loss of Heat to Air or Backing, the Heated Area Is Many Times Larger for the Thin Plate Than for the Thick

Heat losses to air and backing are larger for sheet than for plate, and welding speeds usually are higher for sheet

venting the normal loss of heat to the air. As a result, cooling rates will be slower in the covered electrode bead than in the bare.

For practical purposes the rate of heat input is expressed simply by the current. As we increase the current, holding welding speed constant, the cooling rates fall, Fig. 4. In the same way if we change to a larger tip in gas welding without increasing the speed of welding, we melt more metal and the brown-purple boundary is farther from the weld.

MASS

It is a common experience to observe how far the temper colors spread around a weld in thin sheet, while if the torch is moved at the same rate over a $^3/_4$-inch plate, temper colors scarcely appear under the flame. The explanation is that the sheet is backed up by air, which conducts heat only $^1/_{1000}$ as rapidly as steel, whereas the surface layers of the plate are backed up by more steel, which is an excellent conductor compared with air. The heat supplied to the plate goes to raise the temperature of a hemispherical mass of steel $^3/_4$ inch in radius, Fig. 5. The same heat supplied to the sheet heats the same amount of steel (to the same average temperature). The same temper colors will be found 10 times as far from the torch in the sheet as in the plate, as the very approximate calculations suggest.

Some experimental results on the effect of plate thickness are given in Fig. 6. After 1 minute the unmelted metal close to the bead on the $^1/_4$-inch plate had cooled to 300° C., whereas after the same lapse of time the

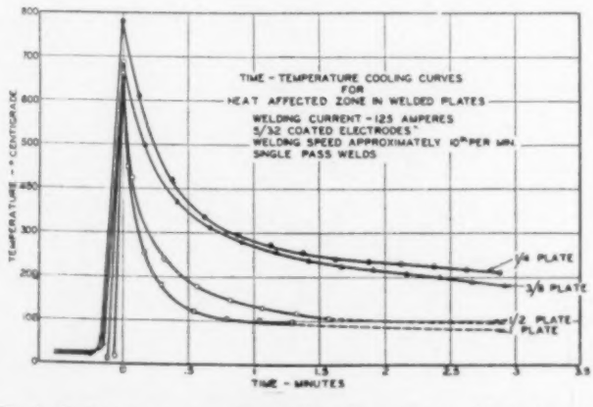

Fig. 6—Cooling Curves for a Single Bead Deposited on the Surface of a Plate. (Emerson)

Instantaneous cooling rates calculated from the cooling curves are:

Temperature, ° C.	Cooling Rates ° C. per Second		
	1/4-Inch Plate	3/8-Inch Plate	1-Inch Plate
700	23	60	100
500	12	55	90
400	6	22	32
300	2	10	19
225	1/4		
200		3 1/3	8
150		1 3/4	4 3/3
100		0	1/11

corresponding point in the plate 1 inch thick had reached 100° C. The significance of the difference between 100° and 300° C. will be obvious to anyone familiar with the term "martensite" and will be explained in a later section.

Even with the same plate thickness we can change the mass of metal around the weld bead by depositing the bead on the edge of a plate or in the angle between two

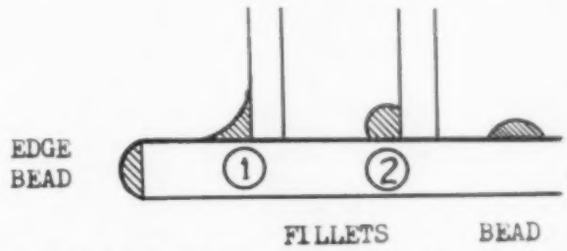

Fig. 7—Shape of Bead, Area of Contact with Plate and Mass of Surrounding Metal Affect Cooling Rates

From the standpoint of cooling rates the edge weld may be imagined as one half of a butt weld. Consequently, the temper colors are the same at the same distance from a butt weld as from a fillet weld made with 50% higher current. (Wilkinson)

plates, Fig. 7. It has been found that for the same welding speed the brown-purple boundary can be made to stop at the same distance from the edge bead as from the fillet bead by using $^1/_3$ as much current on the edge as on the fillet. In other words, cooling rates will be the same when the fillet is given three times the rate of heat input. The conclusions we reached in the section on "Rate of Heat Input" are applicable, therefore, only when the mass of metal around the weld is the same for all welds. Mass effect may be expressed quantitatively by expressing the rate of heat input as heat per unit thickness.

The heat supplied to the edge bead in Fig. 7 can flow in only one direction, whereas the heat in the fillet can flow into both plates. The outlook expressed in Fig. 5 should be applied to Fig. 7. To be strictly comparable, the area of contact of bead with base metal must be the same in both types of weld. Usually the area in contact is higher for a fillet weld than for an edge bead deposited at the same speed and current. For this reason, among others, the cooling rates and dangers from cracking are pronounced in fillet welds. For a given throat size, different shapes of fillets differ widely in contact area. For instance, a convex fillet, Fig. 7, deposited by a bare electrode (short arc) has a low contact area. It will cool slowly compared with the concave fillet 1 which is in contact with base metal over a wide area. A bead deposited at the root of a V butt weld resembles a fillet bead from the standpoint of temperature distribution and cooling rates. The last bead deposited in a twenty-layer butt weld acts instead like a surface bead.

Will the end of a weld cool at a faster rate than the beginning? It is largely a question of mass. If the weld is made from the center of the plate toward an edge, the end of the weld at the edge will cool more slowly than the beginning. On the other hand, if the weld is made toward a corner, where several members intersect, the chilling action of the mass of metal at the cluster will cause the end of the weld to cool at a higher rate than the beginning.

PREHEAT

Preheating procedure involves welding on plates that have been heated to an elevated temperature, and reduces the cooling rate in a given type of weld by lowering the temperature gradient. Instead of the total drop in

temperature of 1480° C. from 1500 to 20° C. that a weld made in plates at room temperature must undergo, the temperature of a weld in plates preheated to 300° C. drops only 1200° C. Cooling rates are reduced particularly at the lower temperatures, such as 700 to 500° C. In multiple-bead welds, the succeeding beads may be deposited on metal that has been preheated by the preceding beads. The more rapidly the beads are deposited upon each other, the higher is the preheat. Needless to say, the first and most important bead is deposited on cold steel, unless preheating procedure is adopted. Since preheating retards the flow of heat away from a weld, the weld metal and slag may be more fluid on preheated metal than on cold—a matter that may be important in judging the welding qualities of an electrode or in vertical welding.

Should it be necessary to weld on steel that is below room temperature, the cooling rates will be unusually high, particularly in the dangerous ranges below 700° C. It will be pointed out in a later section that rapid cooling in the vicinity of 200° or 300° C. may crack welds in some high-strength steels. Welding these steels at unusually low temperatures is risky, because high rates of cooling through the dangerous range are encouraged by the high temperature gradient. Preheating above the dangerous range, of course, avoids the risks. The temper colors spread to a greater distance around preheated welds than around welds made at room temperature. In multiple-bead welding, the depth of the grain refining action of the succeeding bead on the preceding bead is greater if the second bead is deposited at once, than if a long interval elapses between beads.

Questions

1. What is the difference between heat and temperature?
2. Why does the heat from a welding torch or arc spread into the steel in all directions, although the flame or arc impinges only on the surface?
3. Show the connection among temperature gradient, cooling rate, and rate of heat input.
4. When the weld metal freezes it liberates heat. How does the latent heat of solidification affect cooling rates?
5. Other conditions being equal, why will cooling rates be higher in the vicinity of a bead deposited at the root of a multi-layer fillet weld than in the vicinity of a bead deposited at the face?
6. Compare the temperature gradients in gas welding with the temperature gradients in arc welding. Does the temperature of the flame or arc govern the rate of heat input in welding?

R.W.M.A. RECOMMENDED ELECTRODE MATERIALS FOR SPOT WELDING SIMILAR AND DISSIMILAR METALS USING CONVENTIONAL SPOT WELDING METHODS - -

TO WELD SIMILAR METALS

FERROUS

TO WELD SIMILAR METALS READ BLOCK UNDER METAL TO BE WELDED	TIN PLATE STEEL	TERNE PLATE STEEL	GALVANIZED IRON ZINC PLATE	CADMIUM PLATE STEEL	CHROME PLATE STEEL	STAINLESS STEEL 18-8 TYPE	SCALY H.R. STEEL	C.R. STEEL H.R. STEEL CLEAN
TIN PLATE STEEL	B I I 3	A I I 3	A I① I① 3	B I I 3	A II II 3	A III② III②	B I① I① 2	A II II
TERNE PLATE STEEL								
GALVANIZED IRON ZINC PLATE								
CADMIUM PLATE STEEL								
CHROME PLATE STEEL								

NON - FERROUS

TO WELD SIMILAR METALS READ BLOCK UNDER METAL TO BE WELDED	ALUMINUM	ALUMINUM ALLOYS DURALUMINUM	CUPRO NICKEL	NICKEL SILVER	NICKEL	NICKEL ALLOYS MONEL NICHROME (MILK RES)	BRASS YELLOW 35% 40% ZINC	PHOSPHOR BRONZE GRADE A, C & D	SILICON BRONZE EVERDUR OLYMPIC DURONZE HERCULOY
ALUMINUM	B I② I② 2	B I① I① 2	A II II	B II II	A II II	A II II	B II II	A II II	A II II
ALUMINUM ALLOYS DURALUMINUM									
CUPRO NICKEL									
NICKEL SILVER									
NICKEL									
NICKEL ALLOYS MONEL NICHROME (MILK RES)									
BRASS YELLOW 35% 40% ZINC									
PHOSPHOR BRONZE GRADE A, C & D									
SILICON BRONZE EVERDUR OLYMPIC DURONZE HERCULOY									

TO WELD DISSIMILAR METALS

FERROUS ALLOYS	STAINLESS STEEL 18-8 TYPE	CHROME PLATE STEEL	CADMIUM PLATE STEEL	GALVANIZED IRON	TERNE PLATE STEEL	TIN PLATE STEEL
COLD ROLLED STEEL HOT ROLLED STEEL, CLEAN	A II② II	A II II 3	B II II 3	B I II 3	A I② II 3	B I II 3
TIN PLATE STEEL		B II I 3	B I② I 3	B I I 3	B I② I 3	
TERNE PLATE STEEL	B II I 3	B II I 3	B I② I 3	B I I 3		
GALVANIZED IRON ZINC PLATE	B II I 3	B II I 3	B II I 3			
CADMIUM PLATE STEEL	B II I 3	B II I 3				
CHROME PLATE STEEL	A II 3	II② 3				

NON-FERROUS ALLOYS	NICKEL ALLOYS	NICKEL	PHOSPHOR BRONZE	SILICON BRONZE	YELLOW BRASS	NICKEL SILVER
CUPRO NICKEL	B II II		B II II	B II II		B II II
SILICON BRONZE EVERDUR-OLYMPIC DURONZE-HERCULOY			B II II	A II II	B II II	
NICKEL SILVER	B II II I		B II II I	B II II		
NICKEL ALLOYS	A II II	A II II				
STAINLESS STEEL 18-8 - TYPE	B II① II① I	B II② II②				

	ALUMINUM
ALUMINUM ALLOYS DURALUMINUM	B I② I② 2

LEGEND

BLOCK INTERPRETATION

WELDABILITY
A - EXCELLENT
B - GOOD

ELECTRODES
R.W.M.A. SPECIFICATIONS
I - GROUP A CLASS 1
II - GROUP A CLASS 2
III - GROUP A CLASS 3
NOTE: ELECTRODE MATERIALS IN CIRCLES ARE SECOND CHOICE - EXAMPLE ②

SPECIAL INFORMATION
1 - SPECIAL CONDITIONS REQUIRED
2 - GOOD PRACTICE RECOMMENDS CLEANING BEFORE WELDING
3 - IF PLATING IS HEAVY, WELD STRENGTH IS QUESTIONABLE

This chart adopted by the Resistance Welder Manufacturers Association embodies the best general recommendations that can be made for the selection of the proper electrode materials for spot welding similar and dissimilar metals. - -

These recommendations for electrodes can be effective only when the other essential factors of the correct time, current and pressure are properly controlled. - -

Flame Machining—Control and Applications*

By G. L. Walker† and W. G. Sylvester†

THE advantages of flame machining as a formative process for surface shaping operations have long been recognized. It comprehends the controlled removal of metal by surface oxidation, through the medium of an oxygen stream issuing from a properly designed orifice or nozzle, to develop a desired surface contour. The Oxy-Acetylene Committee of the I. A. A. in 1933 classified flame machining and oxygen cutting as the two main subdivisions of oxyacetylene cutting processes. It differs from oxygen cutting in that it does not entail severing operations but is confined principally to processing or shaping metal surfaces. In certain operations, however, where large quantities of metal are to be removed preparatory to subsequent finish machining, further processing or welding, the combined facilities of flame machining and oxygen cutting are successfully employed. In all such instances, the selective applications of the processes are contingent upon the relative suitabilities of the processed metal for the intended operation and the resulting economies realized.

Oxygen cutting has been investigated and developed extensively from standpoints of economy, control and application; and recently a more complete realization of the possibilities of flame machining and the increased demands of industry for more closely controlled dimensional tolerances has inspired refinements in technique and apparatus to advance flame machining to a precision process. Since an oxygen stream is substituted for the machine tool bit or cutter and metal removal is accomplished by an exothermic chemical reaction rather than by physical means, the necessity for a more complete understanding of the operating variables becomes obvious.

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The velocity of the oxygen stream and the preheat intensity can be suitably controlled through proper functional design of the flame machining tip. However, it remains necessary to determine the interrelation of the tip size, preheat intensity, oxygen pressure, speed of traverse and angle of tip relative to work piece in order to specify proper procedures for a given operation.

CLASSIFICATIONS OF FLAME MACHINING PROCESSES

For purposes of deducing certain correlationships in the subclassifications of flame machining processes, the chart shown as Fig. 1 has been developed. It was found expedient also to use the relative motion between the flame machining tip and work piece as a basis for classification.

To enumerate and subclassify the various processes as commercially used, the following definitions are applicable:

A. Flame Planing

Manual or machine guided flame milling operations defined by rectilinear motion between flame machining tip and work piece.

1. Surface Planing.—The process of removing wide surfaces by means of several adjacent and overlapping surface cuts preparatory to subsequent rolling or finish machining. The basic surface cuts produced by suitable orifice designs range from oval-shaped to relatively flat contours. The operation may be performed either by repeatedly passing a flame machining tip over the surface in a given sequence of passes or by the simultaneous action of several tips manifolded for unitary operation. The removal of entire surfaces of billets, slabs and rounds to eliminate surface seams or defects represents one

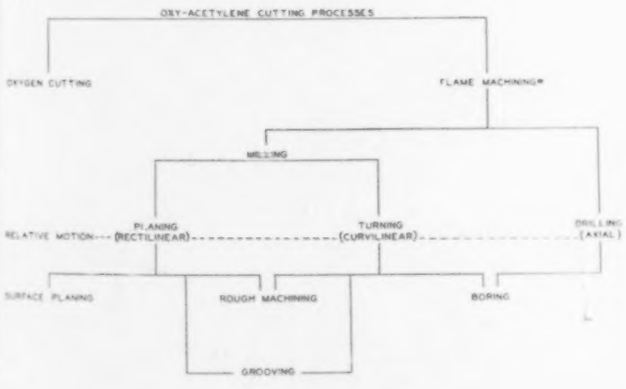


Fig. 1—Classifications of Flame Machining Processes

Fig. 2—Classifications of Flame Milled Grooves

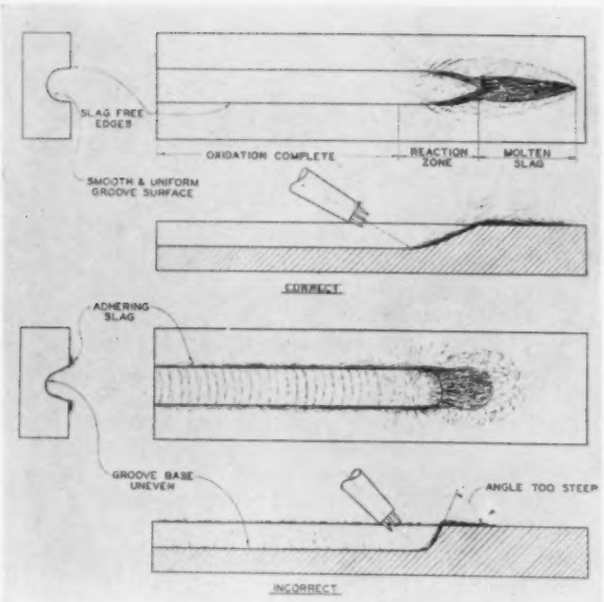


Fig. 3—Grooving Process

application known in practice as "skinning." The lightening of sections by this procedure also finds economical application in foundries and steel mills. Further subclassifications are:

a. Deseaming: The process of selectively removing seams, cracks, laps and other defects in billets, slabs and rounds by application of one or more trailing or overlapping surface cuts. This operation is also known as "scarfing" in steel mill practice. In addition to the higher production rates and lower cost of surface processing effected by flame deseaming, the added advantages of quiet operation as compared with chipping and grinding and of light portable equipment are also realized.

b. Gouging: A flame planing process for removing superfluous metal or "padding" added to steel castings to insure soundness in the finish machined surface. Gouging in steel foundry practice is known as "hogging" when it is used to replace or supplement straight line cutting for the removal of risers and sprues.

B. Flame Turning

A machine guided flame milling process similar to flame planing except that the relative motion between the flame machining tip and work piece is curvilinear. Turning down surfaces of shafts, fillet cutting and processing the edges of dished heads, circular plates and either inner or outer surfaces of hollow cylindrical vessels are typical applications. Subclassifications are rough machining and flame grooving. As these operations are applicable to both flame planing and flame turning, they are discussed jointly as follows:

1. Rough Machining.—A machine guided process for removing excess metal by flame turning or flame planing methods to a tolerance suitable for subsequent finish machining. In certain applications where large masses of metal are to be removed, the combined facilities of flame grooving and flame cutting can be economically and satisfactorily employed.

2. Flame Grooving.—A manual or machine guided flame turning or flame planing process intended principally for the development of deep and relatively narrow grooves. This process, because of its flexibility and the variations in groove dimensions possible, has been successfully used for plate edge preparation and surface grooving for welding, also as an auxiliary process with flame cutting for rough machining. In salvaging operations, the removal of welds and rivet heads by this process reduces base metal damage to a minimum.

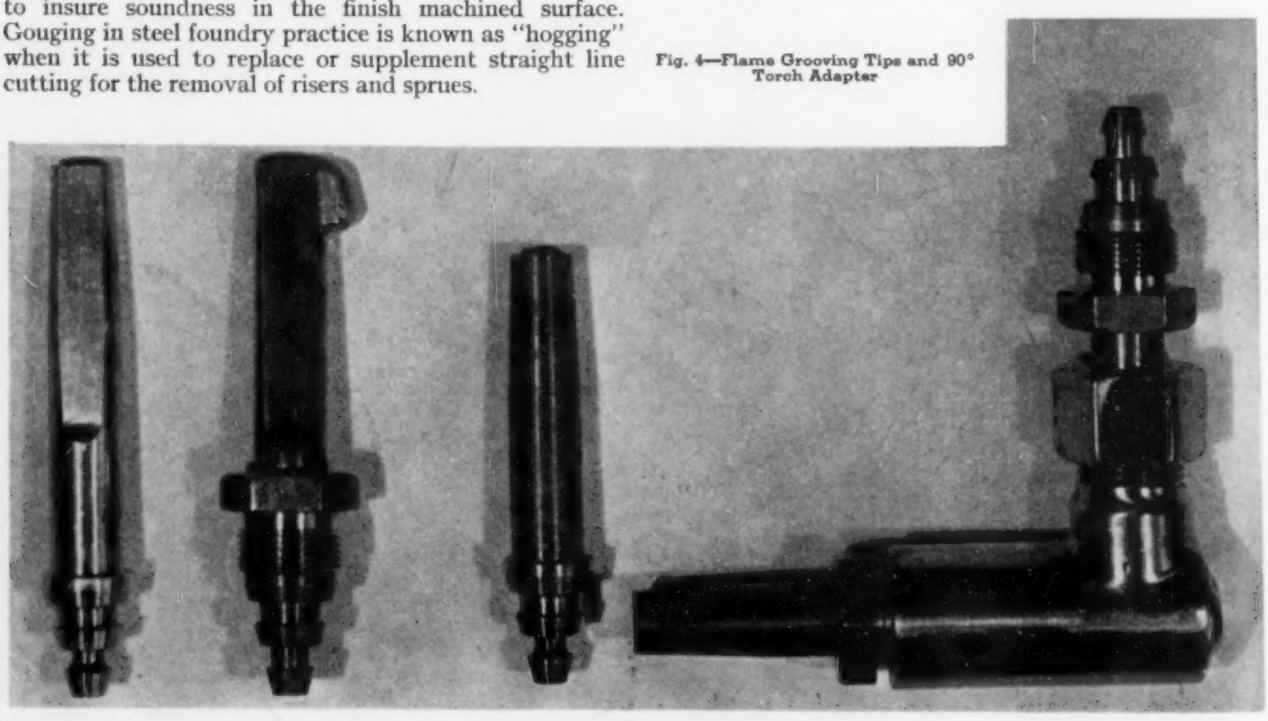
C. Flame Drilling

Manual or machine guided flame machining process in which the relative motion between the flame machining tip and work piece is axial in direction and may be of an oscillatory nature or stationary.

1. Boring.—A process for metal removal performed by flame drilling or flame turning includes such operations as billet end centering, lance piercing heavy sections and the removal of countersunk rivets and bolts.

The classification of the several processes in accordance with the relative motion between the flame machining tip and the work piece enables a further comparative study of the processes themselves.

Fig. 4—Flame Grooving Tips and 90° Torch Adapter



Since the majority of the surface processing methods used are subclassifications of flame planing and flame turning, the ensuing analysis of flame machining will be confined principally to a further study of these latter processes. In this connection, a clear distinction between the operating conditions required for surface planing and flame grooving can be developed. Figure 2 shows a tabulation of the more important factors and their comparative influence on the finished groove dimensions typical for each of these processes. The relative advantages of each type of surface processing as intended for a specific operation are realized in their respective fields of application as previously outlined.

FLAME GROOVING PROCESS

A comparison of the operating conditions necessary to develop a surface groove by the surface planing and flame grooving methods places the latter process in a rather unique position. As the relative speeds of traverse, oxygen pressures and oxygen stream velocities are considerably lower for flame grooving, they are individually and hence in aggregate more readily controlled to develop and maintain a desired surface contour. It follows, therefore, that the attainment of groove widths, depths and base radii to close dimensional tolerances depends upon an accurate knowledge of the interrelation of the operating factors involved.

The more important independent variables to be considered for economical and dimensionally accurate grooves are as follows:

1. Design and size of grooving tip orifice
2. Oxygen operating pressure
3. Grooving speed
4. Angle of incidence of the grooving oxygen stream to work plate
5. Quality of material and surface condition
6. Preheat intensity
7. Smoothness of grooving orifice.

Figure 3 illustrates schematically a machine guided flame grooving process and stresses the importance of suitably disposing and operating the grooving tip.

The optimum in smooth and uniform groove surfaces with slag-free edges requires the following precautions:

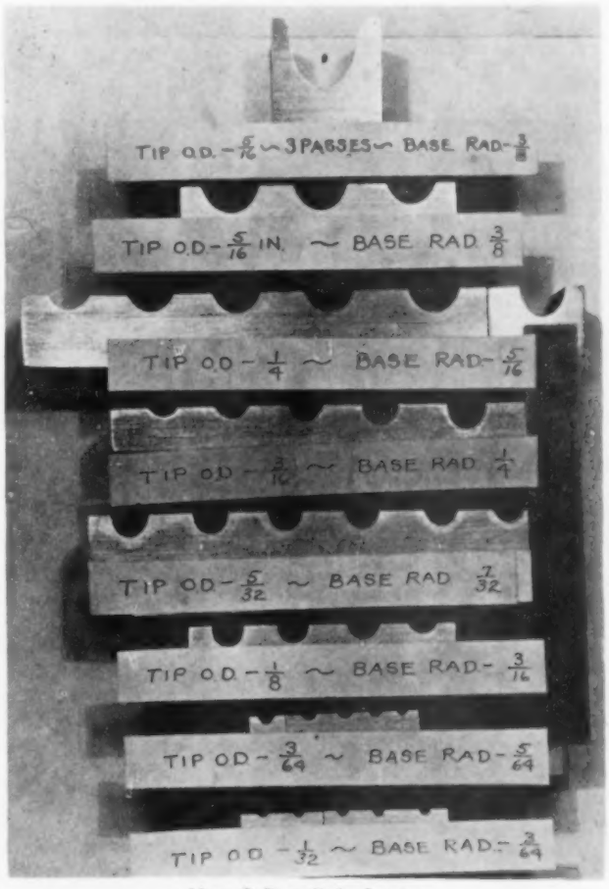
1. Use of a balanced operating speed and oxygen pressure for a given angle of oxygen impingement to the surface to attain the desired groove dimensions as well as a stable reaction zone progressing at the tip speed of traverse.
2. Selection of the best combination of independent operating variables to completely discharge the products of reaction forward along the axis of the groove while maintaining an axially symmetrical and somewhat elongated zone of reaction.

From the chemistry of oxygen reaction the heat developed by the combustion of 1 lb. iron with the theoretical requirement of 4.6 cu. ft. of oxygen is 2900 Btu. The ensuing high temperature of reaction melts some of the iron as well as heats a thin film of the base metal up to the ignition or kindling temperature of about 1600° F. This permits further progressive oxidation by continuous evolvement of heat thus effectively sustaining the grooving process. Failure to attain the proper balance of operating conditions results in the following:

1. A back flow of slag and molten iron into the base of the groove to cause the surface to become rippled and uneven.
2. An excessively steep angle of discharge of the reaction products permits a side wash of molten slag which adheres to the edges of the groove.
3. The molten slag carried to the surface in advance of the groove is dispersed over a large area and fails to concentrate the heat of the molten slag as well as the heat developed during its further oxidation on the surface. This results in an irregular zone of reaction, the axis of which is constantly changing in direction with resulting non-symmetrical side walls of the groove.
4. The groove may run out because of excessive speed of traverse or insufficient oxygen to sustain the oxidation reaction.

CLASSIFICATION OF TIPS

As a guide for oxygen cutting processes, there are available tables of data which specify tip sizes for cutting given plate thicknesses including recommended speeds of traverse, oxygen pressures and length of drag for highest quality and most economical cuts. The advantages of an analogous operating guide for flame grooving processes are immediately perceptible. However, in addition to the operating variables involved in oxygen cutting, flame grooving necessarily includes another independent variable, namely, angle of incidence of the grooving oxygen stream to the surface of the work plate, or, briefly, the tip angle. In view of this, a comparative performance index was established for a range of tip sizes using as a basis the mean base radius of the grooves developed for each orifice diameter.


TIP O.D. - 5/16 ~ 3 PASSES ~ BASE RAD - 3/8
TIP O.D. - 5/16 IN. ~ BASE RAD 3/8
TIP O.D - 1/4 ~ BASE RAD - 5/16
TIP O.D - 5/16 ~ BASE RAD 1/4
TIP O.D - 5/32 ~ BASE RAD 7/32
TIP O.D - 1/8 ~ BASE RAD - 3/16
TIP O.D - 3/64 ~ BASE RAD - 5/64
TIP O.D - 1/32 ~ BASE RAD - 3/64

Note: O. D. = Orifice Diameter

Fig. 5—Groove Profiles Developed by Flame Grooving Process

The grooving tips used were of the low oxygen velocity type with exit orifice diameters ranging from $^1/_{32}$ to $^5/_{16}$ inch in suitable size increments. Figure 4 shows three styles of flame grooving tips having comparable oxygen orifices but with variations in external design to perform selective grooving operations. An adapter for straight machine cutting torches to enable flame grooving of plate edges is also shown.

The survey of tip performance comprehended speeds of traverse ranging from 12 to 48 inches per minute, tip angles up to 30° and grooving oxygen pressures up to 50 lb. per sq. in. The flame machining apparatus consisted of a three-hose machine flame cutting torch equipped with 90° head and mounted on a standard motor-driven machine which was guided by tracks to produce straight line grooving. In this manner, uniformity of torch movement at selected operating speeds, tip angles and tip spacings relative to the work plate could be maintained. Figure 5 shows profiles of grooves on plates machine grooved at proper speeds to give good quality grooves for each tip size.

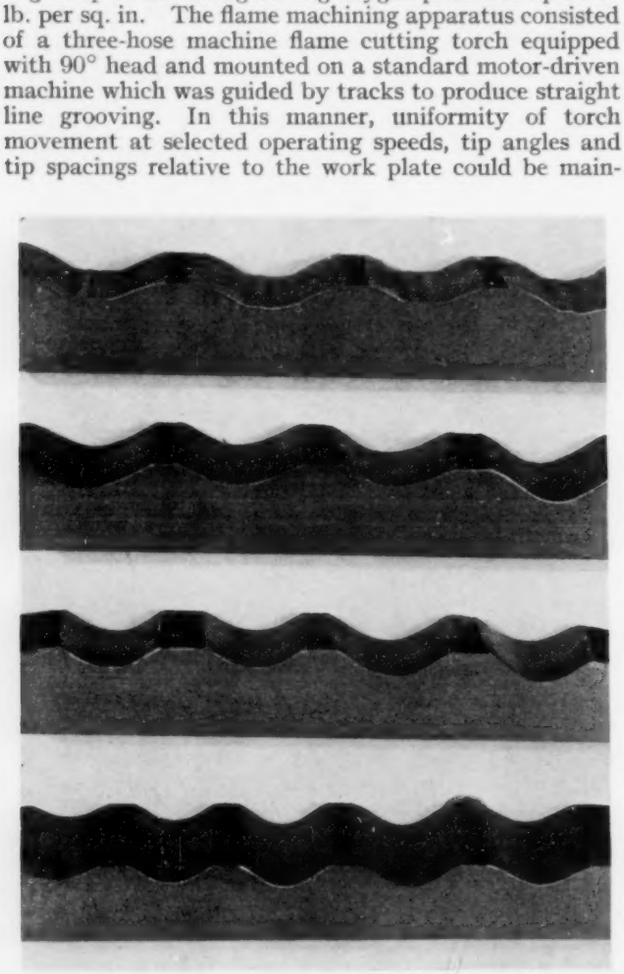


Fig. 6—Typical Surface Contours Developed by Surface Planing Process

The dimensional variations of the grooves shown for a given tip were developed by increasing the oxygen pressures while maintaining constant, the speed of traverse and tip angle settings. Comparable variations in groove dimensions for a given tip size are developed by fixing any two of the three independent variables, namely, the speed of traverse, tip angle and oxygen pressure, and properly varying the third. Increasing the tip angles or decreasing the speeds are further examples of procedure control to give increasing groove depths.

For comparison with Fig. 5, showing the basic types of grooves developed by machine guided flame grooving, Fig. 6 shows the profile and surface of the basic groove types commonly used for surface planing operations.

The relatively wide and shallow grooves tapering to a slight angle at the width extremities satisfactorily process the surface and leave it suitable for such subsequent operations as rolling or finish machining.

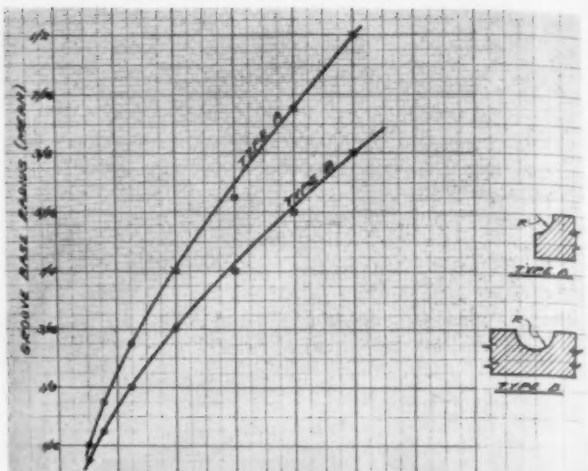


Fig. 7—Relation Between Tip Size and Base Radius of Grooves

Figure 7 shows the relationship between the mean groove base radius and tip orifice exit diameter as affected by type of groove developed.

Type "A" illustrates the flame grooving process as applied to a plate edge while type "B" represents the basic surface groove types shown in profile on Fig. 5 above.

The selection of the mean value of the groove base radii as a basis for rating the performance of tips implies a knowledge of the magnitude of deviation from this mean for each tip.

Figure 8 shows this variation with tip angle as affected by grooving speeds and tip size.

For groove depths equal to the mean base radius for each of the tips investigated, the maximum deviation

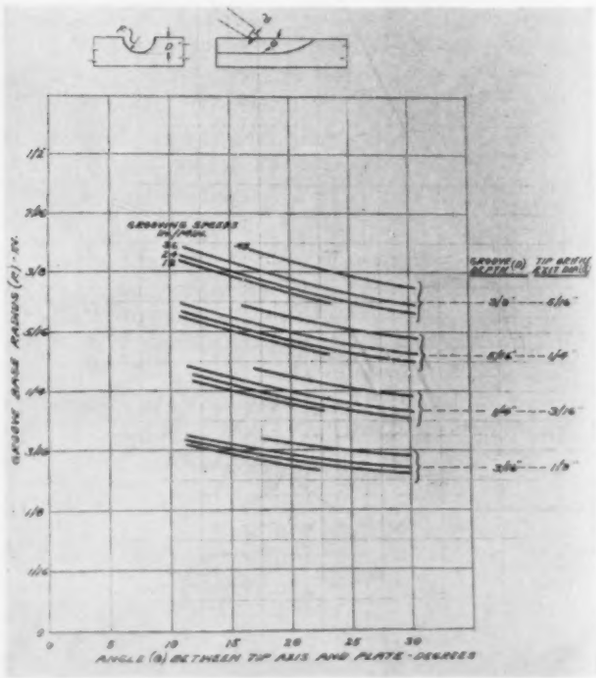


Fig. 8—Groove Base Radius vs. Tip Angle as Affected by Grooving Speed and Tip Size

of the groove radius from the mean value was plus or minus $^1/_{16}$ inch. The curves also serve to bear out the decrease in groove base radius with increasing angle as well as with decreasing speeds.

DIMENSIONAL ANALYSIS OF GROOVES

The development of a clear definition for basic considerations of grooving tip performance, namely, the interrelation of the groove base radius and tip size, also facilitates in predicting and correlating the dimensions of groove depth and groove width. However, before a desired surface contour can be developed and controlled to close dimensional limits, an accurate knowledge of the individual and combined effects of the operating variables must be determined. The scope of this analysis, therefore, necessarily includes a detailed investigation of each of the independent variables, such as tip size, oxygen pressure, grooving speed and tip angle within the limits imposed by critical conditions for satisfactory grooving.

Accordingly, a logical sequence of controlled grooving procedures for surface grooving was outlined to determine these necessary operating data with the following objectives in mind:

1. To develop, for each tip size investigated, the most satisfactory range and combination of operating variables for the control and accurate duplication of a given groove contour.
2. To study the dimensional relationships of groove width to depth for a given tip size in order to determine the relative suitabilities of such groove contours for specific applications.
3. To investigate the grooving oxygen economies as affected by variations in independently controlled operating variables.

The tips selected for this study were limited to orifice diameters of $^1/_8$, $^3/_{16}$ and $^1/_4$ inch, which are grooving tip sizes whose commercial applications have been most versatile in scope. The apparatus and range of operating speeds, grooving oxygen pressures and tip angles were identical to those used for classifying the performance of tips in terms of their groove base radii.

The grooving procedures were essentially as follows: The three-hose torch mounted in an adjustable holder was set to give a desired tip angle with the plate surface, allowing approximately $^1/_{64}$ inch spacing between tip face and work plate. The tip preheat intensity was varied slightly with operating speeds to maintain the rate of preheat reasonably constant. For a given tip angle and speed setting, the operating pressures used ranged from a lower critical, or that pressure which would not sustain continuous grooving, to an upper critical which was too high for developing smooth and uniform groove contours.

In surface grooving as in oxygen cutting the equilibrium conditions between the oxidation reaction and the tip speed of traverse are reached very soon after the grooving process is initiated. Nevertheless, the grooves developed at operating pressures between the upper and lower critical, that is, the serviceable pressure range, were allowed to progress considerably beyond the equilibrium point to insure continued performance with non-varying results. Grooved surfaces with maximum variations of $^1/_{64}$ inch for any one dimension have been successfully developed and repeatedly maintained. To insure comparable operating conditions, the steel plates were cooled to room temperature before subsequent grooving of the plate surface. To enable accurate measurement of the groove depth, width and base radius, the grooved plates were sectioned in planes normal to the groove axes, thus presenting a sharp-edged profile of the groove contours.

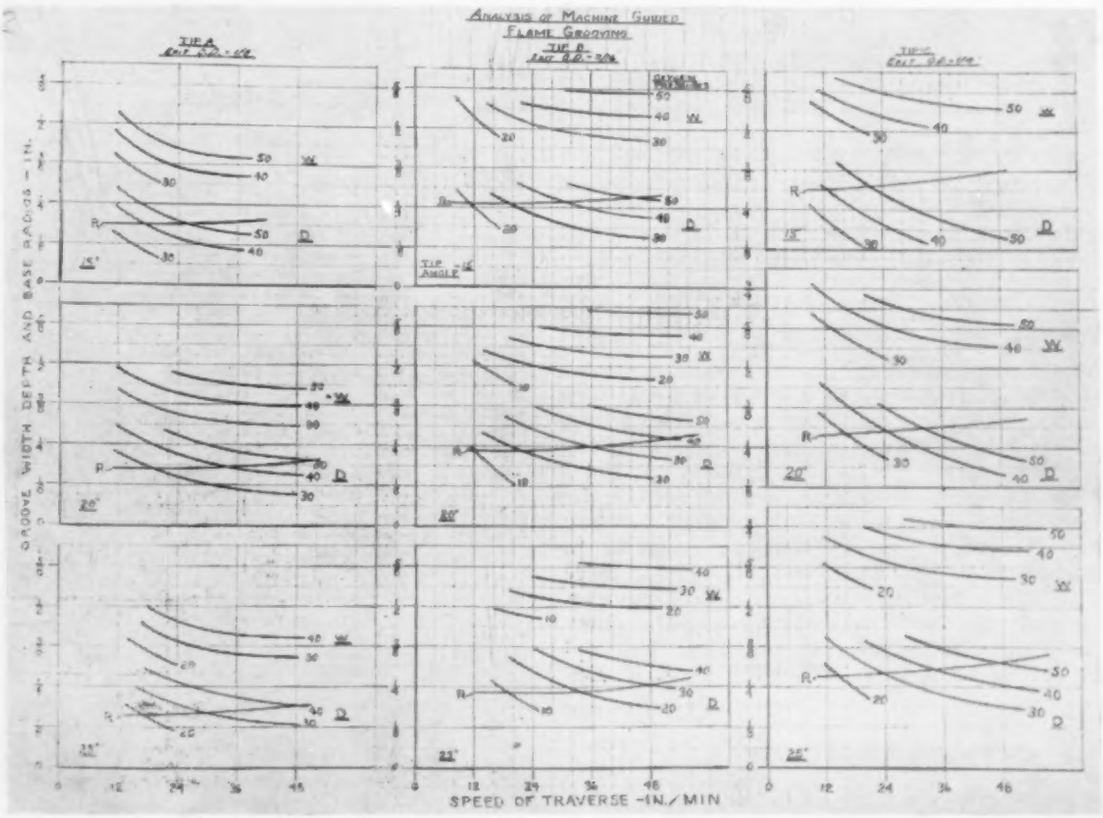


Fig. 9—Dimensional Analysis of Grooves Developed by the Machine Guided Flame Grooving Process

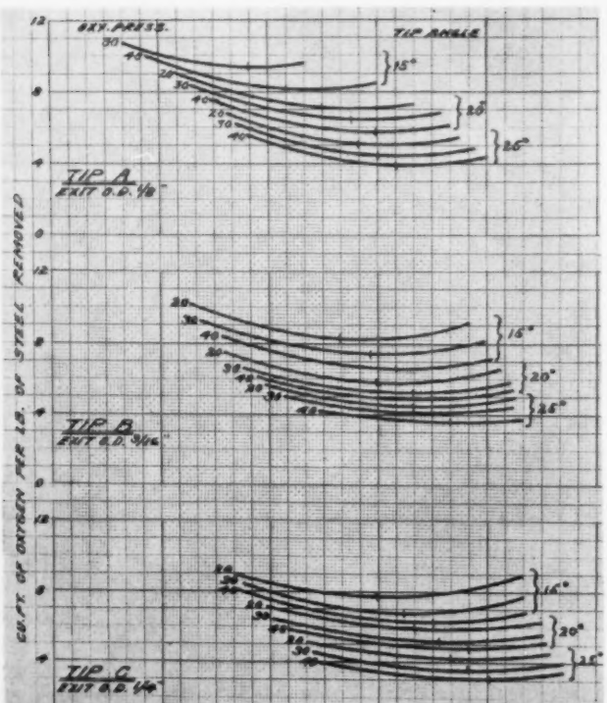


Fig. 10—Variation of Specific Oxygen Consumption with Independent Operating Variables

An analysis of the results obtained by these machine-guided flame grooving operations is shown graphically in Fig. 9.

To facilitate comparisons, the interrelation of the independent operating variables and variations in groove dimensions for each tip size are shown for three tip angles, namely, 15, 20 and 25 degrees. For each tip angle noted the groove widths, depths and base radii are developed for fixed pressures as a function of the grooving speed.

The lower speed terminus of each of the constant pressure curves represents the upper critical pressure for the tip angle and grooving speed indicated. In like manner, the higher speed terminus of these curves represents the lower critical pressure for the indicated tip angle and speed.

From the relationships expressed by the curves, the following very significant conclusions are logically drawn:

1. For the constant pressure curves shown, the ratio of groove width to groove depth varies from a value less than 2 to a value greater than 2 when progressing from the upper to the lower critical pressure extremities of the curves.

2. It follows, therefore, that at certain points on the base radius curves there are located suitable operating pressures for producing groove contours whose depth equals the base radius and whose width is equal to twice the depth. These profiles are essentially semicircular. From this study the necessary operating conditions may be selected to produce grooves varying from deep and relatively narrow to shallow and relatively wide contours.

GROOVING TIP EFFICIENCY

Since for a given tip size a number of combinations of independent operating variables exist which will produce grooves with but minor discrepancies in contour dimensions, a rational basis for selecting specific operating conditions is necessary. A feasible approach toward this goal is the grooving oxygen consumption requirement for a specified weight of steel removed.

When expressed in units of cubic feet of grooving oxygen per pound of steel removed, this ratio may be designated as the "specific oxygen requirement" and used to define the relative efficiencies of the grooving tips. From accurate measurements of the grooving oxygen consumption, speed of traverse and groove contour dimensions, the integrated volume and, therefore, the weight of steel removed were determined for a corresponding volume of grooving oxygen consumed.

Figure 10 expresses the interrelation of specific oxygen consumption and grooving speed as affected by tip angle and grooving oxygen pressures.

It was found expedient for this analysis to use grooving oxygen pressures of 20, 30 and 40 lb. per sq. in. common for the three tip sizes indicated and as operated at tip angles of 15, 20 and 25 degrees. In certain instances, however, operating data outside the range required for good quality grooves were included to study further trends of the constant pressure curves.

For a given operating pressure and tip angle there is a definite or ideal speed at which a minimum value is obtained for the specific oxygen requirement. At operating speeds greater or less than that defined by this minimum value, the efficiency of the grooving process and, hence, that of the tip is relatively lower. In general, for a given orifice size, the relative grooving oxygen efficiency, as defined by inflections of the constant pressure curves, increases with increasing grooving speeds, oxygen pressures and tip angles.

If, in addition to the operating pressures noted on

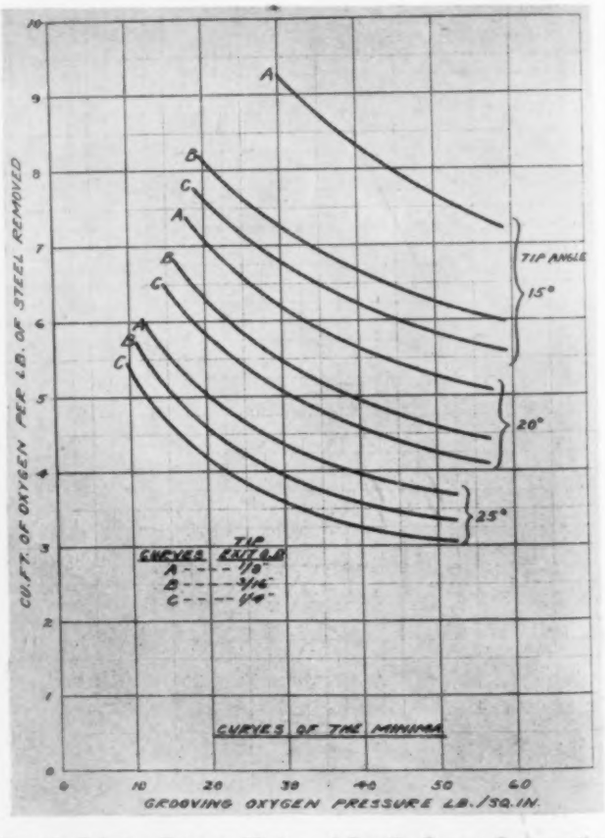


Fig. 11—Relation Between Minima of Specific Oxygen Consumptions and Oxygen Pressure as Affected by Tip Size and Tip Angle

② HIGHEST QUALITY GROOVES
③ MOST ECONOMICAL GROOVES
SPEED IN/MIN
③ PRESSURE LB/SQ IN
GROOVING OXY CONSUMPTION CU FT/HR
TIP EXIT O.D. IN
④ PHT ACET CONSUMPTION CU FT/HR
SPEED IN/MIN
③ PRESSURE LB/SQ IN
GROOVING OXY CONSUMPTION CU FT/HR
14-30 25-30 150-170 1/8 30-40 30-38 30-35 170-190
30-38 30-35 340-380 3/16 45-60 38-44 35-40 380-420
38-42 35-40 430-475 1/4 50-65 40-48 45-50 520-560
25°-25° TIP ANGLE 45°-30°
① SMOOTH GROOVE SURFACES WITH VERY UNIFORM CONTOURS
② BASED ON SPECIFIC OXYGEN CONSUMPTION OF GROOVING OXYGEN ONLY
③ REGULATOR PRESSURES AT ENTRANCE TO 12-1/2 FT-3/8 IN HOSE AND QUICK ACTING SHUT-OFF VALVE
④ AHT OXYGEN EQUAL TO PHT ACETYLENE CONSUMPTION

Fig. 12—Approximate Conditions Essential for Economical Machine Guided Flame Grooving

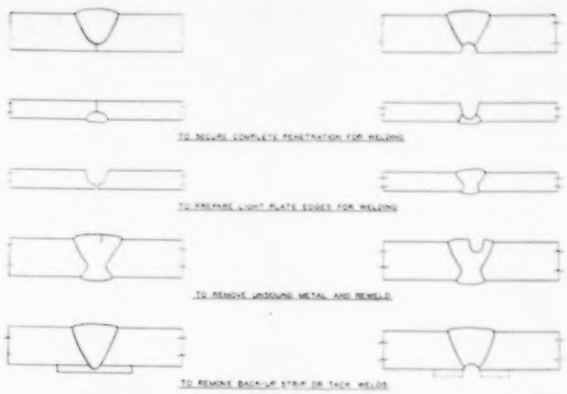

TO SECURE COMPLETE PENETRATION FOR WELDING
TO PREPARE LIGHT PLATE EDGES FOR WELDING
TO REMOVE UNSOUND METAL AND REWELD
TO REMOVE BACK-UP STRIP OR TACK WELDS

Fig. 13—Further Applications of Flame Milled Grooving Operations

Fig. 10, the entire pressure range from 10 to 50 lb. per sq. in. is investigated in smaller increments of pressure and the minimum values for the specific oxygen consumption thus obtained are plotted, the results shown on Fig. 11 are developed.

These curves express the minimum specific oxygen consumption *vs.* grooving oxygen pressure as influenced by tip size and tip angle. It is significant to note that the minima for the specific oxygen requirement decrease with increasing tip angles and with increasing orifice size.

The higher tip efficiencies obtained with increasing tip angles are due principally to the steeper angles of oxygen impingement with the surface. However, the ideal speeds for maximum tip efficiency increase with tip angle and require a proportional increase in grooving pressures to obtain a given groove depth. This combination of increased pressures and speeds to accommodate steeper angles reaches a practical limit imposed by considerations of control over the dimensions of groove contours. In view of these interrelated factors, it was found expedient not to exceed tip angles of 30° for machine-guided flame grooving processes.

For fixed operating pressures, tip angles and corresponding ideal grooving speeds, the slightly higher tip efficiencies developed with the larger orifice diameters are most readily explained by a purely dimensional analysis. A more explicit treatment would necessarily include an elaborate survey of the relevant factors involved in steel oxidation reactions. Briefly, the doubling of an oxygen stream diameter serves to double the stream periphery while the volume increases four times Moreover, the rate of oxygen stream polution with entrained air and combustion gases remains substantially constant for a given functional tip design operating at a constant inlet pressure. Under these conditions, the larger stream diameters experience less stream dilution and present a larger volume of high purity oxygen to the reaction zone. The availability of this relatively higher concentration of undiluted oxygen for the larger tips is reflected in proportionately higher tip efficiencies for the grooving process.

This rather extensive analysis of dimensional control, augmented by the further survey of grooving oxygen economies, has been coordinated to develop operating procedures for machine-guided flame grooving processes. Figure 12 shows a tabulation of operating variables comprehending the approximate conditions essential for grooving surfaces most economically and for higher quality results.

As is characteristic for oxygen cutting, the higher quality results for surface grooving are also obtained at relatively lower speeds and oxygen pressures.

The existence of wide variations in quality of material, surface conditions and cleanliness of grooving tip will necessarily require some deviation from the operating conditions specified. Moreover, in grooving operations performed manually the operating data selected will vary with the individual skill of the operator as well as with the nature of the operation performed. However, the successful application of the data specified in either manual or machine-guided flame grooving processes is dependent upon a knowledge of the interrelation of the operating variables as developed for controlling groove contours to specified limits.

APPLICATIONS OF FLAME GROOVING PROCESS

A comprehensive survey of the applications of manual and machine-guided flame grooving processes permits their classification under two distinct headings:

1. As an individual process to produce groove contours for further selective operations
2. As an auxiliary process, with oxygen cutting, for flame machining large surface contours to specified limits.

Under the first classification flame grooving has been successfully used for salvaging and rough machining operations and for surface processing preparatory for welding. The removal of entire welds and rivet heads with a minimum of thermal or physical damage to the salvaged parts, and fillet cutting of sharp edges and corner joints are typical applications of salvaging and rough machining. In surface processing for subsequent welding, the versatility of the grooving process is manifested

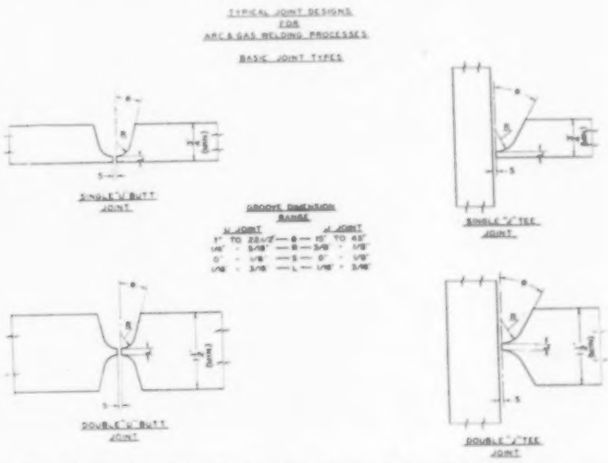


Fig. 14—Typical Joint Designs for Arc- and Gas-Welding Processes

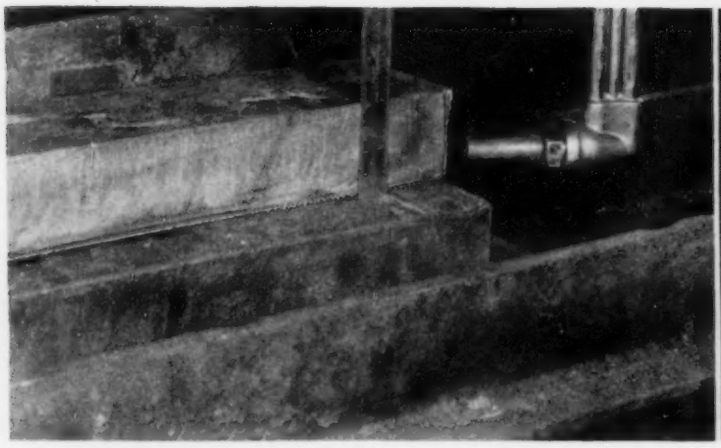


Fig. 15—Grooving Tip in Position for Grooving Plate Edge

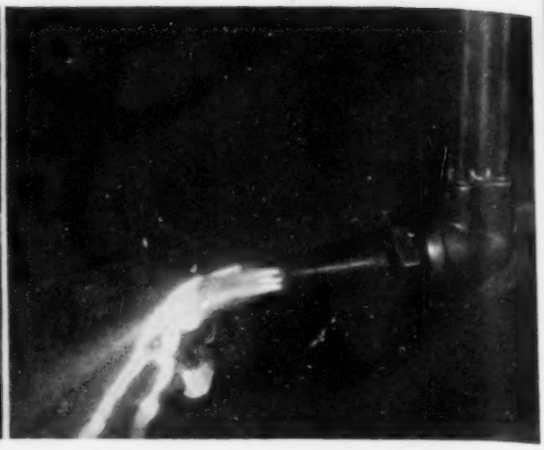


Fig. 16—Typical Grooving Process in Action

through various controlled operations. Some of the more important of these are shown schematically in Fig. 13.

With the operating data and procedure control previously developed, as a guide, the grooving operations indicated may be performed manually in one or more passes with satisfactory control of the groove dimensions. Surface defects, $^3/_8$ to $^1/_2$ inch deep and with varying linear dimensions, can be removed satisfactorily in one pass of the grooving tip. The groove contours developed have suitable base radii with sidewall included angles ranging from 0 to 30 degrees, as desired, to facilitate electrode or welding rod clearance for rewelding the groove.

The removal of subsurface cracks or defects in welds, steel castings or structural shapes as revealed by X-ray, gamma ray or by surface inspection is a further application of flame grooving. When the defects or cracks extend below the surface to depths beyond the range possible with a single pass of the grooving tip, several superimposed grooving passes are necessary. The first one or two passes developed should produce grooves whose width to depth ratio is approximately 3 to 1. These are followed by one or more comparatively deep and narrow grooves whose width to depth ratio is equal to or less than 2 to 1. This selective grooving procedure reduces metal removal to a minimum while developing deep, narrow, U-shaped grooves with ample width at the upper surface to facilitate complete rewelding. Unlike chipping or grinding processes, the removal of unsound metal by flame grooving is assured as the defects or cracks are clearly visible as contrasting dark spots or lines, respectively, in the reaction zone. The grooving process is continued linearly or repeated, if necessary, until such evidence of defects no longer recurs during a given grooving operation.

The preparation of plate edges with single "U" or "J" joints on lighter plates, $^3/_8$ to $^5/_8$ inch in thickness, or of double "U" or "J" joints on plates $^3/_4$ to $1^1/_4$ inches in thickness can be satisfactorily developed and controlled by grooving operations only. The grooving procedures required for processing the plate edges with a single "U" or "J" joint are essentially duplicated for developing the double "U" or "J" joint types. The groove base radius is controlled through selection of proper tip size and angle of tip to the plate edge in the horizontal plane, whereas the desired sidewall angle of bevel of the groove and the required land dimension are controlled by locating the grooving tip in the vertical plane at a predetermined height relative to the plate surface.

The procedure described for preparing plate edges, by using the grooving process alone, develops grooves whose contour dimensions become increasingly difficult to control as the plate thicknesses increase. This is primarily due to the reciprocal relationship existing between the

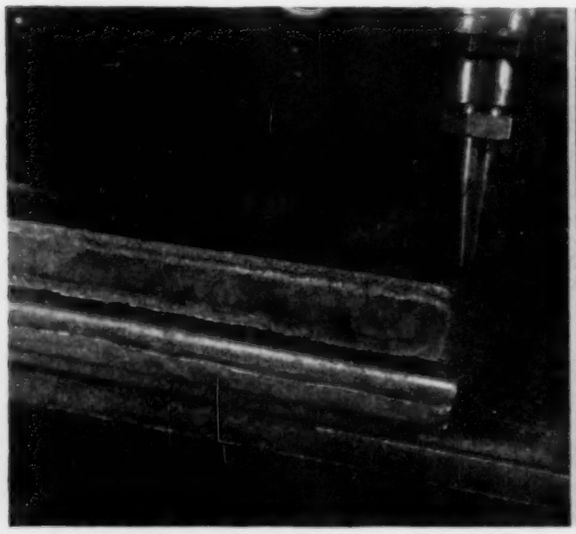


Fig. 17—Grooved Plate Edge with Cutting Tip in Position for Bevel Cutting to Groove

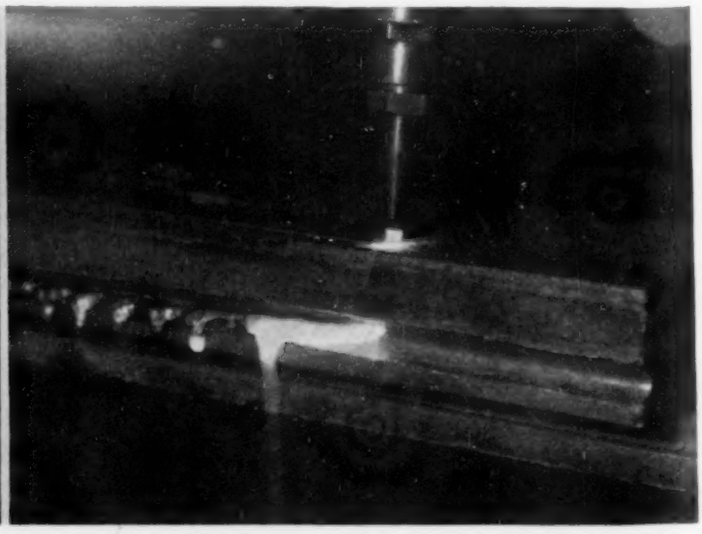


Fig. 18—Bevel Cutting Operation in Action

magnitudes of the angle of bevel and base radius of the groove as developed by a single oxidation process.

Nevertheless, the advantages of the "U" and "J" joint designs for welding heavier plate thicknesses have been widely known and are principally as follows:

1. Less weld metal is necessary per welded "U" or "J" joint as compared with the plain beveled joint types.
2. More efficient deposition of initial weld metal beads or layers are effected by the "U"-shaped base of the joint.

Therefore, the development of an accurate and economical procedure for flame machining heavier plate thicknesses to dimensional tolerances suitable for automatic welding processes would add considerable moment toward expanding the field for standard oxyacetylene equipment.

Figure 14 shows the basic "U" and "J" joint types as generally recommended for heavier plate thicknesses.

The dimension range indicated for groove radius and angle of bevel represents a consensus of those most commonly used in commercial practice. The numerous combinations of tip angles and base radii possible for the plate thicknesses shown necessarily preclude their successful development by means of a single grooving or oxidation process. Since this implies a flame-machining technique which will insure accurate control of both base radius and angle of bevel, the combined facilities of flame grooving and oxygen cutting immediately suggest themselves.

Figures 15 through 19 present in proper sequence the fundamental steps necessary to produce the basic "U" and "J" types of joints by these methods.

Figure 15 shows a grooving tip mounted in a standard three-hose oxygen cutting torch equipped with 90° head. The grooving oxygen orifice size and operating conditions are selected from the surface grooving data developed earlier to obtain semicircular grooves with the proper radius. The tip height relative to the bottom surface of the plate is adjusted to leave the land dimension specified for the particular joint being developed. Figure 16 represents a typical grooving operation of a plate edge in action. Figure 17 shows a grooved plate edge with a machine-cutting torch and tip located on the upper surface of the plate and properly inclined to cut at a desired angle of bevel. The tip is disposed at a suitable distance back from the plate edge to enable the bevel cut to penetrate to the groove tangent with its inner surface. Figure 18 shows the bevel cutting operation to the groove in action.

The bevel cutting conditions are those necessary for developing smooth accurate cuts through plate thicknesses equivalent to the distance from the plate surface to the groove. The slag discharged into the groove is easily dislodged by a light chisel blow, leaving a clean groove surface. Figure 19 shows the surface quality of the flame grooved and bevel cut plate edge as well as the single "U" joint profile formed by butting two flame machined plate edges together. A partially welded and etched section of the "U" joint is also shown to illustrate good base penetration and fusion of the side walls of the joint. Following the completion of the upper portion of the weld, the bottom side of the welded joint is grooved and welded to secure full penetration through the land dimension shown.

Figure 20 shows the profile views of plate edges prepared by means of the combined grooving and bevel cutting as well as individual grooving technique. Joints *A* through *D* represent single-"U" butt joint types developed on plate thicknesses of 3, 2, 1 and $^1/_2$ inches, respectively. Joint *E* represents a closed root single-"U" edge joint. The profile *F* is a double-"U" butt joint on 2-inch plate while profiles *G* and *H* show two forms of single "J" corner joints.

To prepare plate edges with single-"U" or "J" joints requiring land dimensions of $^1/_{16}$ inch the plate to be grooved is mounted over a suitable quench plate to equalize the thermal effects of the grooving process on the relatively thin land. Land dimensions above $^1/_{16}$ inch are satisfactorily maintained without this precaution.

The fundamental steps shown for plate edge preparation in Figs. 15 through 19 may be suitably applied to prepare the edges of a number of adjoining plates with single or double-"U" or "J" joints. The plates are assembled on a suitable work bed or table with the edges to be processed, located in a common plane. A waste plate approximately 2 inches wide may be placed in advance of the work plates to insure a clean-cut edge contour for the first plate processed. To flame machine plates with rough sheared or irregular edges, a machine

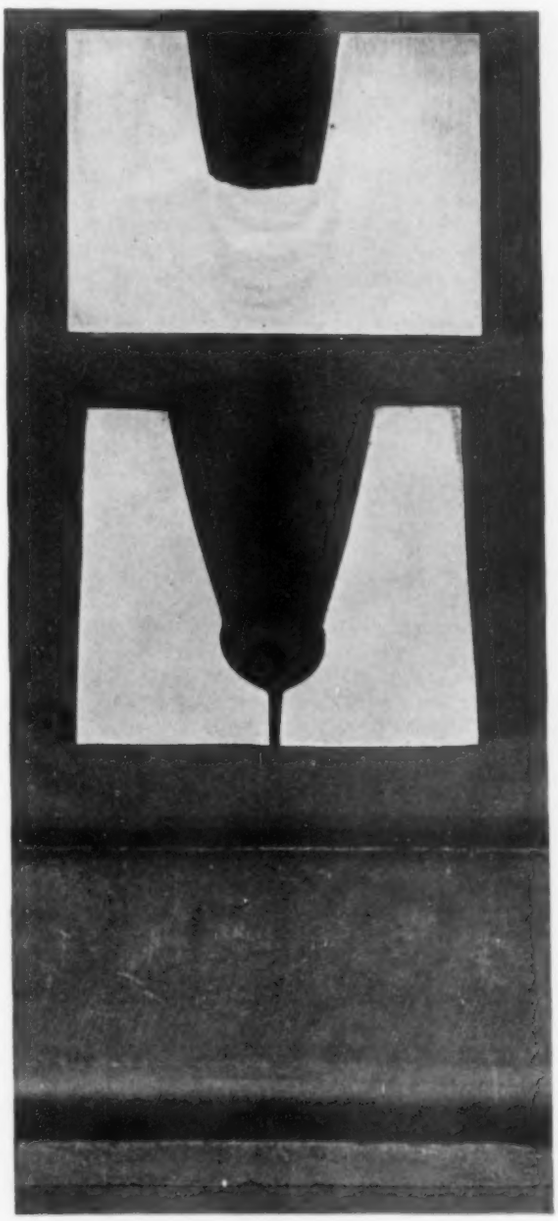


Fig. 19—Completely Processed Plate Edge Showing Single-"U" Butt Joint Profile, Also Partly Welded Joint

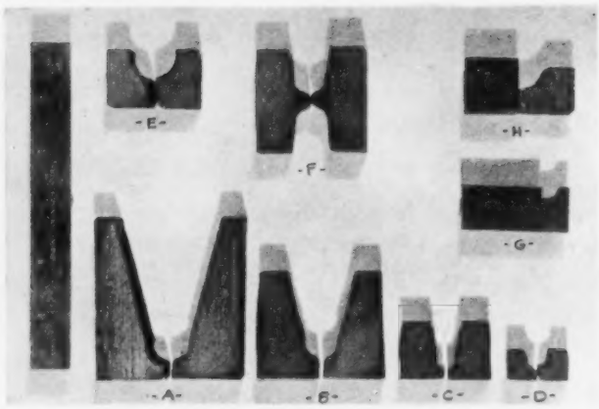


Fig. 20—Variations in Flame Machined Plate Edge Profiles Developed by Individual Grooving as Well as the Combined Grooving and Bevel Cutting Technique

flame cutting operation may be necessary to develop a common plane for the adjoining plate edges. The desired location of the grooving and cutting tips relative to the plate edges is maintained by mounting the torches on a floating carriage comprehending the features of a four-bar linkage or parallelogram. By maintaining constant the grooving tip angle and space settings relative to the plate edge, the groove and land dimensions thus obtained are not affected by surface discontinuities in the plate edges. In like manner, a groove riding device, proceeding in advance of the bevel cutting operation, sustains a given setting of the bevel cut to the groove.

Figure 21 shows schematically the grooving process for multiple plate edge preparation to develop single and double-"U" or "J" joints.

Double grooving performed with two tips spaced to provide a desired land dimension followed by a double beveling operation is also shown.

ROUGH MACHINING

The economies and procedure control realized by this method of flame machining are applied satisfactorily to certain rough machining operations. Figure 22, sketch *A*, shows a method of turning down ends of shafts by successive multiple grooving and cutting operations.

With an allowance of approximately $^1/_8$ inch for finish machining, the metal to be removed is subdivided into even increments of width and thickness. The grooving is accomplished by one or more tips disposed tangentially with the working surface, which is turned toward the tips at suitable surface speeds to enable continuous grooving. A straight cutting operation from the end face of the shaft to the base of the grooves is performed by turning the shaft relative to the tip at surface speeds suitable for cutting the desired thickness. In this manner, several sleeves of metal may be satisfactorily removed to a given rough machining tolerance without excessive heating of the base metal.

Sketches *B* and *D* represent two linear operations for shaping or lightening sections by the combined multiple grooving and bevel cutting processes. The operations *A*, *B* and *D* show strips of unoxidized waste metal, which represent oxygen economies as compared with such complete oxidation methods as surface planing. Sketches *C* and *E* indicate two methods of processing intermediate surfaces of shafts accomplished by varying the rate of cross feed of the grooving tip relative to the turning shaft. In all cases of flame grooving whether by the flame planing or flame turning processes, successful results are contingent upon the control and maintenance of a proper combination of operating variables relative to the work piece.

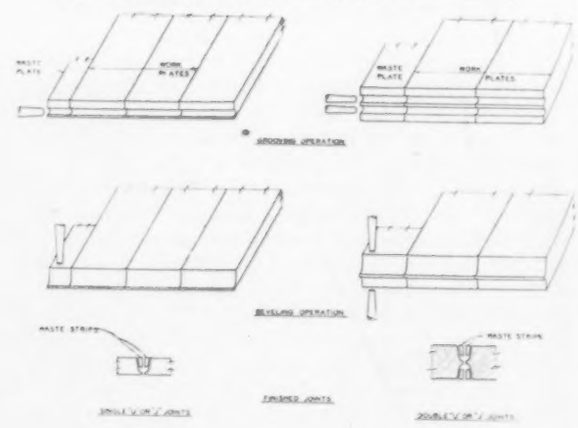
METALLURGICAL CONSIDERATIONS

The methods of rough machining or preparation of plate edges for welding by the combined flame grooving and bevel cutting technique offer no additional metallurgical problems than those resulting from straight flame beveling operations. The A. S. M. E. Boiler Code Specifications for fusion welding permit carbon steels up to 0.35° C. to be processed for subsequent welding by oxy-acetylene methods. As the thermal effects of welding remove all metallurgical changes introduced during grooving, no revisions in existing codes which permit flame cutting are necessary to include the grooving process. In general, the same precautions for preheating and controlled cooling are necessary when grooving higher carbon or special alloy steels in plate, cast or forged condition as are required when processing them by flame cutting or welding.

SUMMARY

The classification of flame machining processes in accordance with the relative motion between the flame machining tip and work piece enables a further compara-

Fig. 21—Multiple Plate Edge Preparation for Welding



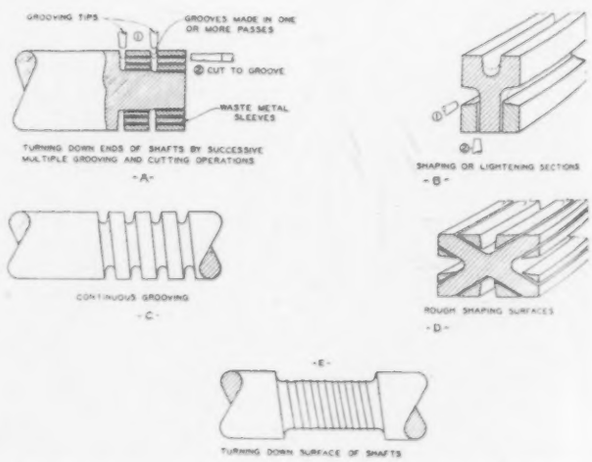


Fig. 22—Rough Machining by Individual Grooving and Multiple Grooving and Bevel Cutting Methods

tive study of the processes themselves. From a comparison of the operating requirements and the nature of the processed surface as intended for specific subsequent operations, a clear distinction between surface planing and flame grooving is possible. The distinguishing feature of the latter process is the dimensional control of surface contours effected through its essential operating requirements of low speed of traverse, low oxygen pressure and low oxygen stream velocity. A knowledge of the factors essential for controlled operation, augmented by a predictable performance from tips classified in accordance with their mean groove base radii, advances flame grooving to a precision process. With operating data developed to define their most economical and highest quality working ranges, the grooving tips are satisfactorily used for individual grooving or as an auxiliary process with oxygen cutting for rough machining and plate edge preparation of heavier plate thicknesses for welding.

For these latter operations the combined features of controlled groove radius and angle of bevel enable the preparation of "U" and "J" joints to specification requirements. Further, as a considerable portion of the metal removed is in unoxidized metal strip form, this added oxygen economy is realized in selective rough machining operations which are more expediently controlled through proper sequence of flame grooving and oxygen cutting processes.

700-Ton Metal-Working Press Built in 35 Days by Arc Welding

By A. F. Davis*

ELECTRIC arc welding made possible the remarkable feat of building the huge press shown in Figs. 1 and 2 in the short time of 35 working days from the idea to operation.

This press was designed and engineered exclusively for arc-welded construction. The welding employed was the modern shielded arc process.

* Vice-President, The Lincoln Electric Co., Cleveland, Ohio.

The tremendous size of this metal-forming monster is indicated in the base construction. (See Fig. 3.) The billets used for slide guides are 8 inches thick, while plate used in the balance of the structure is 3 inches. In the illustration, welders are making final tack welds preparing the base of the press for heavy welding in the flat position.

In Fig. 4 can be seen the use of oxyacetylene pantograph for cutting connecting rod links from 6-inch bar stock. In the background a supervisor is checking two crank shafts which were cut from 6-inch plate by the oxyacetylene cutting machine.

With the wide experience of the builder, R. G. Le Tourneau, Inc., which uses no other process of construction except arc welding, plus modern flame cutting machinery, construction of the press was not a difficult undertaking. It was simply a case of working out the design for welded construction, cutting the parts from

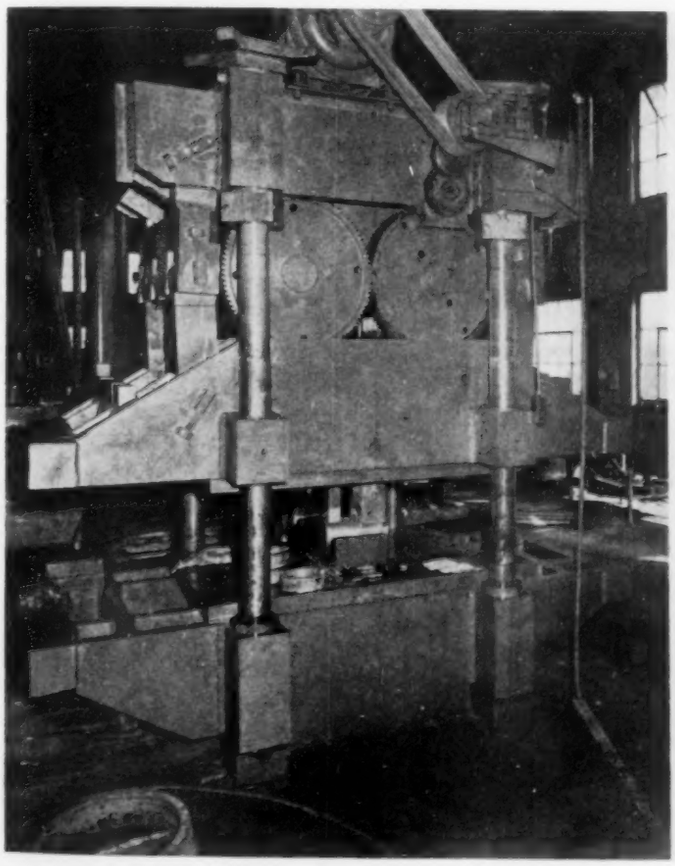


Fig. 1—700-Ton Metal-Forming Press Fabricated by Arc Welding in the Remarkably Short Time of 35 Working Days

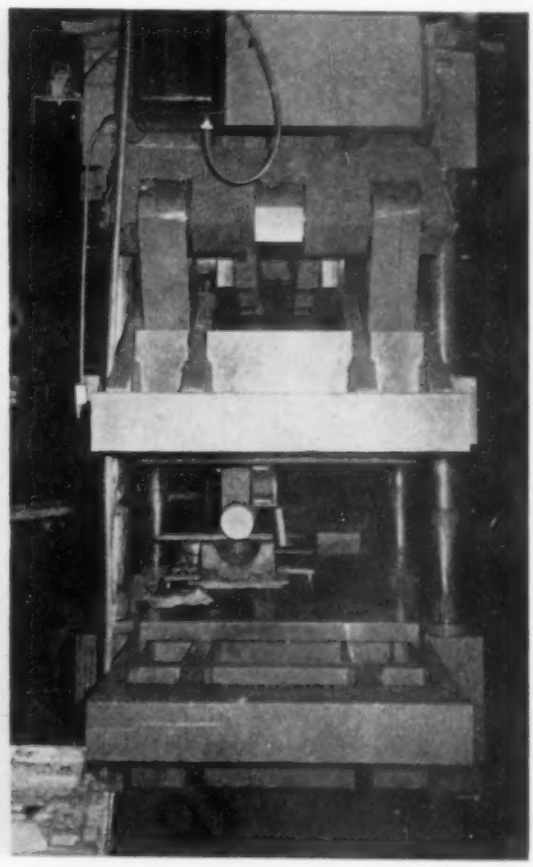


Fig. 2—View of Press Showing Massive Construction Using Heavy Steel Plate Arc Welded

Fig. 3—Making the Final Tack Welds to Prepare the Base of the Le Tourneau Press for the Heavy Welding in Flat Position. Note Thickness of Members Used in Construction

Fig. 4—Utilizing Flame Cutting to Cut Connecting Rod Links from 6-Inch Bar Stock. In Background, a Supervisor Is Checking Two Crank Shafts Cut from 6-Inch Plate by the Acetylene Flame

standard plate and shapes and fusing these parts together. Proper procedure control for welding, together with the efficient positioning equipment developed by the builder, made the unusual feat possible.

The idea of the press, which is to be utilized to fabricate 4-foot by 8-foot panels for all-steel arc-welded houses, came to R. G. Le Tourneau while making one of his many trips by plane. At an elevation of 7000 feet, the rough sketches for the design were completed and two weeks later the engineering department had finished the final plans. At the same time standard structural shapes had been cut and were ready for fabrication.

This striking feat of modern machine production by welding suggests how existing bottlenecks in the American Industrial Defense Program could be broken. This press could never have been produced in such a short time without welding. Efficient designing, special procedures for controlling expansion and contraction, together with use of modern electrodes and welders, set this new record in machinery production. Four welders and one set-up man welded the entire press structure in $3^1/_2$ days.

Capitalizing on the fast production speed and the high structural quality which welding makes available, industry would find the process a powerful ally in speeding the National Defense Program.

Present Trends in Arc Welding

By W. W. Reddie*

THE steady trend toward arc welding has been greatly accelerated, particularly during the last six months by the pressing need for rapid expansion of welding capacity in all branches of metal fabrication to meet the defense program requirements. Analysis and observation show that the pressure to obtain production has intensified the careful selection of methods best adapted for specific operations. Increasing attention has been focused on economy of the welding operation, the operating efficiency over-all machine performance and first cost.

Use Higher Capacities

In the larger welding operations, economy of operation obtained by positioning the work and using high current downhand electrodes with attendant higher rates of metal deposition has emphasized the trend to more high capacity welding units—400-ampere direct-current and 500-ampere alternating-current units.

More attention is being paid to weld appearance, uniformity and soundness, without sacrifice in speed. This, if anything, tends to produce higher average weld quality with more exacting demands on electrode performance.

New operating requirements are being met by im-

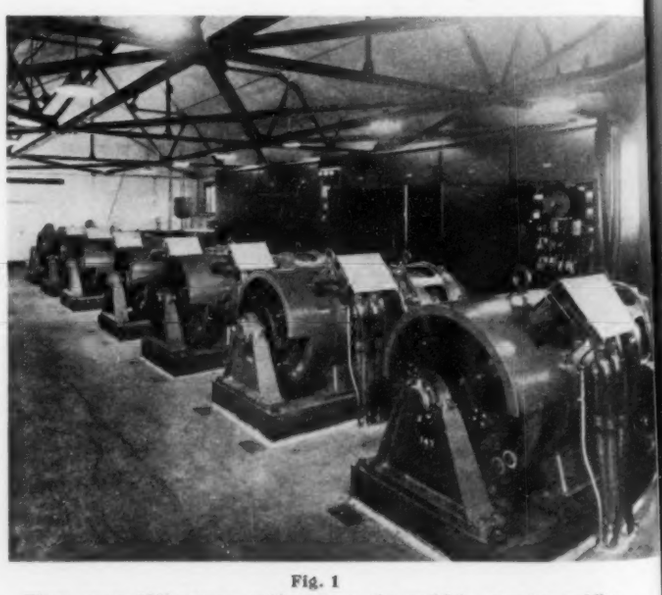


Fig. 1

These seven 1500-ampere welders serve the multiple operator welding circuits in a large shipyard. The sets operate in parallel, and on installations of this size, each set is usually figured to serve an average of 30 operators. Its operating efficiency, normally comparatively low, increases rapidly where large numbers of operators, working at relatively low load factors, are employed. For this reason, such equipment is highly favored in shipbuilding operations.

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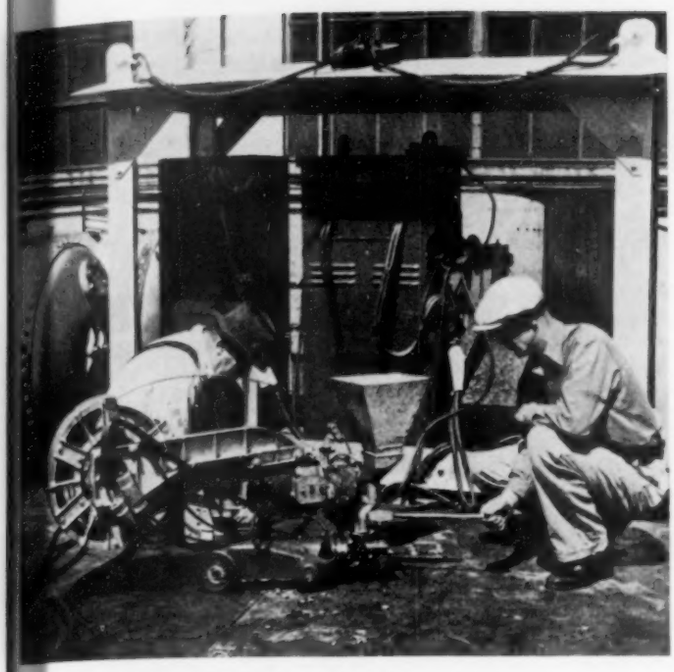

Fig. 2

For high-speed heavy-duty welding asper formed by Unionmelt process, developed by The Linde Air Products Co., A.C. 1000-ampere welders with wide current ranges which may be operated singly or in parallel are said to be efficient and economical, as illustrated by 1000-ampere unit (mounted with its control in portable cradle) supplying current to automatic welding head set in position to make welds in 1-inch plate in foreground. On some installations as many as four 1000-ampere welders are used in parallel, providing current range from 200 to 4800 amperes. Current changes are made under load without shifting electrical connections. Method is claimed to produce high quality welds at increased speed, thus expediting welded fabrication of ships, cars, tanks and pressure vessels.

proved direct-current single operator, alternating-current single operator and multiple operator direct-current welders. For example, they now operate outdoors without cumbersome covers or canopies; alternating-current transformer units for powering automatic welders have reached unprecedented capacities and often use 2300-volt primaries avoiding one step of power transformation. Other notable trends are the low cost—but adequate—sets for mass training of operators for the defense program and the increasing attention toward safeguarding the operator by improved electrode holders and better codes of safe practice.

Work Outdoors

Outdoor operation of single operator welders have not been, and are not now considered, weather-proof. Canopies of steel and canvas, cumbersome but effective, are ordinarily used to provide protection against severe weather. The trend among most users, operating the machines out of doors, is to require better enclosures on the welders themselves, and now machines have been designed which will withstand almost any weather conditions except driving rain or snowstorms without canopy protection.

Unburden Distribution Lines

The need for placing additional load on existing shop supply circuits without wiring changes and the desirability of keeping down the cost of new installations have focused attention on electrical efficiencies, power factors and no-load losses of arc-welding machines. These conditions have justified the development of high power factor transformer welders—welders with capacitors built into the machines.

A welder does not represent an ideal type of load to which an individual capacitor should be applied, because of the relatively high percentage of idle time and the wide range of load in a diversified operation. Yet where a group of welders are operating together even on widely varying conditions of load and operator diversity factor, capacitors properly selected and applied to the individual welder will raise the average power factor as high as 100% and reduce the total kva. input to a point substantially below the kva. input of an equivalent number of D.C. welders under the same load conditions.

Less Power Needed

For example, a group of ten 500-ampere high power factor welders operating at a load of 375 amperes each and a diversity factor of 60 (six on and four off at any given time) would have an average operating factor of 96% and a total kva. input of 105. A group of ten 400-ampere A.C. motor-driven D.C. welders operating under the same load conditions would have an approximate over-all power factor of 83% and a kva. demand of 195.

More Multiple Operator Welders

Similar considerations of striving for greater economy of operation, economy of first cost and adaptability have emphasized the value of multiple operator D.C. welding systems, consisting of constant potential welding motor generators with individual circuit controls, in many phases of ship-building operations. Load conditions are

Fig. 3

2000-Ampere single A.C. transformer type welder for serving "Unionmelt System." The welder is designed to give current variation over a range from 400 to 2500 amperes. The complete high tension and power control equipment is enclosed in separate cubicle as shown on rear of bedplate. The welder takes power directly from 2300-volt distribution system. The entire assembly may be moved as a unit.

such that it is possible to load these machines with a total connected welding circuit rated load, which far exceeds the actual name-plate rating of the welding generator. The conditions of loading have been developed by experience rather than by engineering calculations.

For example, in some locations, 1500 ampere welders, usually operated in groups of four in parallel, are serving mixed tacker and production welder circuits of a total number which would allow an average, based on generator rating, of but 65 amperes per circuit; in fact, some are as low as 50 amperes per circuit. That is to say, experience shows it is possible to load 6000 amperes of installed capacity with as many as 120 operators, under conditions of sufficiently diversified load. Each operator is provided with his individual circuit control panel usually of 200 or 300 amperes maximum capacity. The welding power plant under these conditions of loading is usually operating at maximum load and maximum efficiency with no idle time losses.

Broadening requirements for multiple operator units require motor generators completely assembled with motor and generator control, thus making up a self-contained welding power substation, which may be picked up as a unit by a crane and moved, when occasion requires, with a minimum amount of wiring change. Welding circuit controls are required for indoor service as well as fully protected for service outdoors without field added protection.

Apply Bigger Welding Transformers

Increasing demands for higher current capacities for serving "Unionmelt Systems" of welding have led to higher capacity welding transformers. Numerous operations simply use a number of 1000 ampere welders operated singly or in parallel according to the requirements of the number of heads installed. It is standard practice to build these units with 220/440 volt primaries for connecting to the regular shop circuits.

Larger single units, dry type, natural air ventilated, have been built for taking power directly from the 2300-volt distribution. Where it is necessary or desirable to take power from 2300-volt systems and still retain the diversity of single 1000-ampere units, a system has been developed employing a high capacity transformer, usually of the "inerteen" insulated type, which transforms from 2300 volts to 100/85 volts for serving a number of controlling reactors connected in multiple. The reactors are of the dry type and are built in fixed or variable combinations.

Production Industries Using Small Welders

In the field of small AC transformer type welders, the trend to using more of these units in the industries on production work is evident. Electrode developments have provided electrodes for practically all classes of welding with these units. If anything the development of AC electrodes may be said without exaggeration to have brought about higher standards for performance for direct current electrodes, because all AC electrodes must show equal performance on DC welding.

The small A.C. welders have been extensively applied in operator training schools. The older school of thought was that beginners should be broken in on bare electrode. That was and is very sound and logical practice for numerous reasons. In the present emergency, when many men must be trained, and quickly, it is not sacrificing too much to start with coated electrodes, provided instructors sufficiently emphasize the basic principles that are considered to be best taught with bare electrodes.

Safety Is Stressed

Safety and teaching of safe practices to operators have received more attention than ever before during the past year. The fact that all arc voltages and machine open circuit voltages are relatively low has doubtless led to some feeling of complacency on the part of builders and users.

Medical opinion and practice does not and cannot fix a "safe" voltage, because the physical characteristics and condition of the individual as well as surrounding working conditions, and character of contact with a circuit, will always vary widely. Conditions that might be considered satisfactory in normal weather may be quite unsatisfactory during protracted hot spells when welders may be sweat soaked and perhaps not in the best physical condition. Consequently, even if thousands of new operators were not being trained and put to work, it would be time to stiffen up on safety practices.

Insulated electrode holders have been improved. Many operators, especially those working on heavy work, prefer to have a short length of unusually flexible cable attached to their holder. This flexibility has heretofore been obtained at the sacrifice of insulation, because an impregnated cotton braid was used instead of rubber as a cable cover. The cable length next to the holder is almost always in contact with the operator and he should have a maximum of protection. The bottom braid does not afford this. A type of "Neoprene" insulated cable has been developed which gives practically the same flexibility as the cotton-covered cable, and without sacrificing insulation values.

In connection with safe operating practices machine open circuit voltages are coming in for more scrutiny. A good rule to have in mind, since the absolute fixing of limits seems impractical, is simply "the lower the better."

Industry Was "Ready"

While no industry should be complacent about its accomplishments, it can be considered to the credit of the Welding Industry—and the term as used here broadly includes the manufacturers of equipment, the organized group of engineers represented by the AMERICAN WELDING SOCIETY and the various industry groups who have standardized their own procedures in conjunction with the AMERICAN WELDING SOCIETY—that this industry was READY. While all the answers have by no means been found and there is still much to be done in having National Codes of Procedure and Operator Qualification Codes, which are universally adopted, nevertheless the industry stepped from the requirements of normal operation into a tremendously accelerated production of welding machines and welded products with a minimum of lost time and no confusion.

Preheating—Welding—Normalizing by Induction Hysteresis*

By C. J. Holslag†

A DEFINITE proved advance in welding, increasing the scope of the art, is the use of induction for heat treatments of welds and adjacent metals, especially alloys.

The most outstanding achievement of this development is its use in power-plant high-pressure piping, boilers, valves and turbine connections. The use of high pressure increases the efficiency so that two kilowatt hours can be made where only one was produced before from the same fuel. High pressure would be impossible without welding as there is no other method of joining capable of withstanding this service.

Welding would be impossible without preheating of the alloys used, whether high carbon, carbon molybdenum or chrome molybdenum. In fact, any alloy that will stand the temperature at this high pressure is probably cold short in regard to welding.

When this problem first arose, namely, the use of alloy steels for high-pressure piping, which were liable to crack without preheating, there was only the use of gas, oil or the electric resistance method available.

Mr. Weisberg, mechanical engineer of the Public Service, presented a paper before the joint session of the AMERICAN WELDING SOCIETY and the American Society of Mechanical Engineers, September 27, 1938, on electric welding with electric induction preheating as compared with gas welding and electric welding with electric resistance preheating and normalizing.

Since then there have been a very great many jobs using this induction hysteresis method which heats the pipe immediately and throughout and which can be

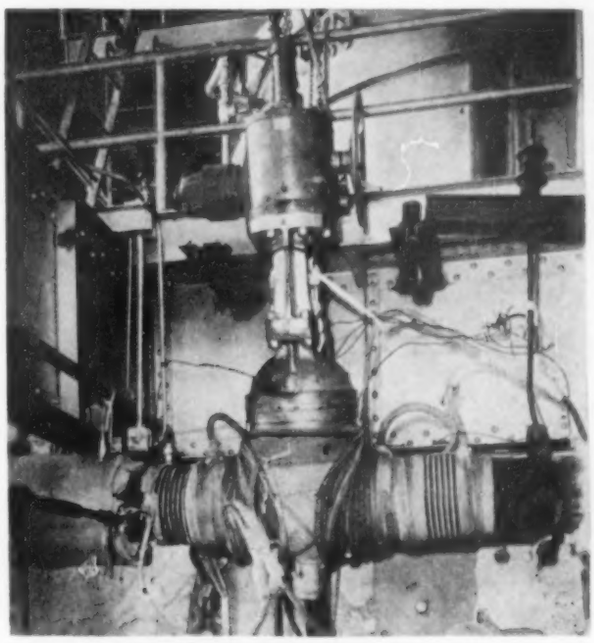

Fig. 1—Stress Relieving Line Joints in Steam Gate Valve

* Presented at the Annual Meeting, A. W. S., Cleveland, Ohio, Oct. 21 to 25, 1940.

† Electric Arc Cutting & Welding Co., Newark, N. J.

Table 1—U. S. Navy Test. Annapolis Experimental Station

50 K.w. Transformer—Draw Treatment

Pipe Size I. P. S.	Wall Thickness, In.	Coil Type	No. of Turns	Insulation	Amp. for Hold.	Holding Temperatures, °F. Center Line	One Quarter Point	Edge*	1/2 In. Beyond Edge	3 1/2 In. Beyond Edge	Remarks
Curved pipe, 6 in.	3/8	Wrapped cable	16	Amosite asbestos covered with asbestos cloth	343	1261	1242	1211	..	1138	Hardened zone (15 in. long) is centered in heated zone (31 in. long)
Curved pipe, 6 in.	3/8	Wrapped cable	16	"	265	1260	1236	1170	1151	1041	Hardened zone (12 in. long) is centered in heated zone (20 in. long)
Curved pipe, 6 in.	3/8	Wrapped cable	16	"	336	1270	1242	1176	1158	1058	Hardened zone (12 in. long) is centered in heated zone (20 in. long)
Curved pipe, 6 in.	3/8	Wrapped cable	16	"	330	1343	1328	1221	1208	1104	Hardened zone (18 in. long) is centered in heated zone (30 in. long)
Curved pipe, 6 in.	3/8	Wrapped cable	16	"	401	1346	1251	1173	..	1061	Hardened zone (15 in. long) is centered in heated zone (32 in. long)
Curved pipe, 6 in.	3/8	Wrapped cable	16	"	394	1361	1294	1217	..	1116	Hardened zone (15 in. long) is centered in heated zone (25 in. long)
Curved pipe	3/8	Wrapped cable	18	4 layers 1/16-in. asbestos paper	401	1346	1373	1337	..	1221	Hardened zone (15 in. long) is centered in heated zone (25 in. long)

* Edge refers to edge of the hardened zone.

Table 2—U. S. Navy Test. Annapolis Experimental Station

1200-Amp. Hatch Type Transformer

Pipe Size I. P. S.	Pipe Size Wall Thickness, In.	Coil Type	Coil No. of Turns	Coil Insulation	Amp. for Hold.	Holding Temperatures, °F. Center Line	Holding Temperatures, °F. One-Quarter Point	Holding Temperatures, °F. Edge*	Holding Temperatures, °F. 1/2 In. Beyond Edge	Holding Temperatures, °F. 3 1/2 In. Beyond Edge	Remarks
6	3/4	Fixed coil	14	2 layers 1/16 in. asbestos paper covered with Amosite asbestos and asbestos cloth	739	1214	1192	1113	1094	1006	
6	3/4	Wrapped cable	12	"	840	1224	1195	1129	1107	1026	
4	9/16	Fixed coil	12	1 layer Amosite asbestos	888	1214	1135	1032	1019	857	Max. current drawn (during heating)—1128 amp. (30 v. tap.).
4	9/16	Wrapped cable	8	1 1/2 layers Amosite asbestos	1322	1164	1132	1042	1000	944	Max. current drawn (during heating)—1512 amp. (30 v. tap.).
2 1/2	1/4	Fixed coil	12	2 layers Amosite asbestos	672	1173	1123	1045	1006	824	Max. current drawn (during heating)—822 amp. (15 v. tap.).
2 1/2	1/4	Wrapped cable	9	2 layers Amosite asbestos and asbestos cloth	893	1158	1025	833	..	..	Max. current drawn (during heating)—1128 amp. (15 v. tap.).
8	7/16	Wrapped cable	26	4 layers 1/16-in. asbestos paper covered with Amosite asbestos and asbestos cloth	624	1397	..	1205	..	..	Temper draw treatment
8	7/16	Wrapped cable	26	Amosite asbestos covered with asbestos cloth	624	1355	..	1250	..	..	.....

* Edge refers to edge of the coil coverage.

controlled within one degree if necessary either manually, by pyrometer or by automatic pyrometer. The record is easily kept by pyrometer readings or from recording pyrometer, either strip chart or round chart, or from a simple log bench method to which the job or jobs are wired for temperature readings. Furthermore, there is now on the market a method developed of measuring preheating and normalizing temperatures by means of melting lozenges made of materials which melt at the temperature stamped on them.

There are many large jobs going on at the present time, using these methods toward the same end. The Burlington plant of the Public Service is being equipped with a high-pressure boiler piping turbine installation using log bench record pyrometer readings with manual welding control. A paper on the welding of the 100,000 kw. turbine boiler installation at Burlington was presented at the New Jersey Section of the A. W. S. by Mr. Salmon of the Public Service of New Jersey and published in the January 1941 issue of THE WELDING JOURNAL.

Philadelphia Electric in its Chester plant, foot of Ward Street, is using automatic recording control with strip chart reading of both the welding conditions and the temperature.

Other similar jobs going on at the present time using round chart automatic control are at the Narragansett Electric, Providence, R. I., and American Gas & Electric Company, Twin Branch Station, Mishawaka, Indiana.

Similar jobs that have already been accomplished with this process are the Schuylkill plant of the Philadelphia Electric, Consolidated Edison, and many others.

The above methods are a proved success as evidenced by 8900 joints welded by this method for the Public Service Essex plant, now in its third year of operation with no failures.

Shipbuilding high-pressure piping has also been accomplished by this process in the same manner, and with the same ease—a special machine called a "hatch" type preheater having been developed to reach the more remote places on shipboard and 200 cycles apparatus mounted on portable wheels with lifting hooks being available and especially applicable to this work. For some work, high frequency is a decided advantage. It reduces the size of cables by reducing the amount of current required. Tricks can be accomplished with it such as stress relieving through three to four inches of lagging already in place on the welded pipe. It is no quicker or better than 50- or 60-cycle static transformer heating but often more convenient.

We have found that from 200 to 240 cycles is ideal for this purpose.

There is available exact data for this use as well as for the regular 60-cycle static transformer apparatus.

Preheating—welding—normalizing in the various large boiler shops has been a standard practice, using a furnace, but there are many instances and many vessels that would not pay to put in a furnace. Furthermore, the furnace control is not as close as is possible by the electric induction method and it is evident that a vessel with many connections would not lend itself to being put in and out of the furnace for each connection.

Here the induction method is ideal and is beginning to be used extensively. Naturally, field connections are very easily accomplished by this method. Vessels which have been preheated and normalized can have certain connections made in the field with the same assurance of relief. Furthermore, large or cumbersome units or those which must be assembled in the field require some method of preheating.

The most noteworthy example of this was the one-inch-thick, 20 feet in diameter, 30 feet long condenser drum, preheated and welded at the Burlington plant of

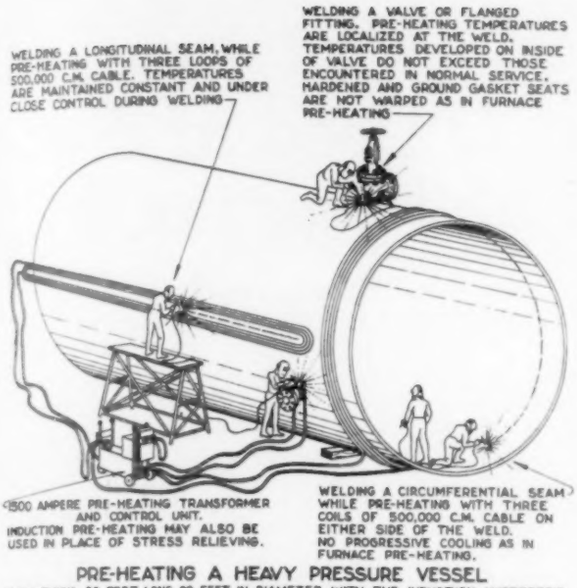
WELDING A LONGITUDINAL SEAM, WHILE PRE-HEATING WITH THREE LOOPS OF 500,000 C.M. CABLE. TEMPERATURES ARE MAINTAINED CONSTANT AND UNDER CLOSE CONTROL DURING WELDING
WELDING A VALVE OR FLANGED FITTING. PRE-HEATING TEMPERATURES ARE LOCALIZED AT THE WELD. TEMPERATURES DEVELOPED ON INSIDE OF VALVE DO NOT EXCEED THOSE ENCOUNTERED IN NORMAL SERVICE. HARDENED AND GROUND GASKET SEATS ARE NOT WARPED AS IN FURNACE PRE-HEATING
1500 AMPERE PRE-HEATING TRANSFORMER AND CONTROL UNIT. INDUCTION PRE-HEATING MAY ALSO BE USED IN PLACE OF STRESS RELIEVING.
WELDING A CIRCUMFERENTIAL SEAM WHILE PRE-HEATING WITH THREE COILS OF 500,000 C.M. CABLE ON EITHER SIDE OF THE WELD. NO PROGRESSIVE COOLING AS IN FURNACE PRE-HEATING.
PRE-HEATING A HEAVY PRESSURE VESSEL
1 INCH THICK, 30 FEET LONG, 20 FEET IN DIAMETER WITH THE INDUCTION HYSTERESIS SYSTEM AS INSTALLED AT THE BURLINGTON PLANT OF THE PUBLIC SERVICE CO. OF N.J.

Fig. 2

the Public Service by the United Engineers, using three preheating apparatus at one time to get the vessel at a uniform temperature.

The oil industry is beginning to use this method. Texas Oil and Indian Refining use it to heat treat chrome molybdenum pipe after welding through a cycle of 1400° F., 1700° F. and back to normal, as required by the metallurgists. This was accomplished by a combination of current through the pipe-resistance heating and induction from the heavy current used. Photographs show how this was accomplished electrically. Test results show what was obtained from a heat-treatment standpoint and the data show that induction is the main heating agent up to 1400° F. and the pipe itself when hot has such a high resistance to normal and eddy currents as to carry the temperature up to melting point if desired.

Any cycle of temperature, up, down or holding at any desired point, can be obtained automatically with the straight induction or the combination resistance, eddy current method.

It would appear that there would be a great use for this electric induction method in oil well welding and capping, being assured that the joints were free of stress. So far we have been unable to get this use accepted.

This electric induction heating for welding is painfully young. We are learning through our customers' experiences as necessity arises. For instance, while welding, the electric induction heat should be off; also while chipping and brushing. The magnetism interferes with all three. This is accomplished by a simple time delay relay which cuts out the electric induction heat when the welding current arc is struck. It keeps the electric heat off for any predetermined time, such as one minute or three minutes, for changing electrodes, chipping, brushing, etc. A master pilot switch is provided also to take the heat off whenever desired, as for continuous welding, because if two men are welding, the welding heat mounts up more rapidly than is desired even where no electric heat is provided.

There is no trouble keeping the preheating temperature at the desired point or, rather, up to the desired point. The welding heat, even with an arc and independent of the induction heat, raises the temperature considerably. This, of course, can be graded by the operator himself, whether from observation or from the automatic record or from a log record or entirely automatically if desired.

The crux of this system is the winding of the six or seven turns required, either high frequency or 60 cycle and much money and time have been spent for the proper method to put on these turns.

Of course, where there is repetitive work, such as production of the same size of drum, piping or connection, a coil either split, clamped, hinged or made in one piece that can be slipped on and off is the best way to do it. The coils can be made of bare copper, flat, round or standard form wound asbestos coils. For repeat jobs, hinged or clamped turns generally of bare edgewise copper, have been used. Generally, however, wrapping is the method of procedure. So far, we have found no insulation that will stand up under this service. We have tried everything I think there is to be had.

Fortunately, plain, bare copper cable for either high frequency or 60 cycles serves the purpose admirably. The cable as shown in the illustration is wound over asbestos paper, just the cheap kind ordinarily used in welding. Perhaps an asbestos blanket cloth is laid over for the welder to work on and to keep some of the heat conserved. The ends of the cable are tied with asbestos tape. This method seems to serve admirably. For instance, some of the bare copper cable that was used on the 1927 Essex job is still being used on the 1940 Burlington job. The more the cable is used, the better it gets. If someone does try a covering on the cable, it soon becomes bare and equally useful.

The temperature pyrometer connections are generally best made by enclosing them in a small piece of eight-inch pipe, tacking this pipe where desired and hammering them flat. The temperature can be taken at any position, inside, outside or anywhere where it is most convenient.

The electric induction method has been used in some strange places. One was the padding up of a diesel engine shaft by one of our big companies, another is for shrink fitting for welding and other uses such as cams and locomotive wheels and tires and, what is equally important, the removal of the shrink fit. It has been used to extend bolts to the right tension in heavy frames where it would have been impractical with locking nuts to ever forecast the exact tension desired. It has also been used to preheat and normalize aeroplane propeller shafts, as shown, the induction method being used on the heavy hub end and the resistance on the feather edge end, combination of the two giving an even temperature throughout. This system has been used on all sizes and shapes from small parts of bookkeeping machines as well as the heaviest castings. This method seems to open up a new field for arc welding. It is evident that any heat treating desired can be accomplished by this apparatus.

I will close this paper by prophesying that in many instances preheating will do away with the necessity of stress relieving. In other words, if the patient is kept from getting sick there is no need to cure him.

How Shape-Cutting Is Used in the Fabrication of Steel Mill Equipment*

By J. W. Stanley†

IN THE past few years, oxyacetylene shape-cutting has literally revolutionized methods for the construction of steel mill equipment. In conjunction with welded fabrication, flame-cutting has made it possible to turn out better products in less time and at less cost than by methods formerly used. It is the purpose of this paper to discuss briefly the reasons why shape-cutting is indispensable in present-day steel mill fabricating shops, and to show how this modern metalworking tool fits into manufacturing operations.

In the fabricating shops of the Lorain Division at Johnstown, a wide variety of products are produced for other plants of Carnegie-Illinois Steel Corporation, as well as for the mines and mills of other subsidiary companies of the United States Steel Corporation. An idea of the diversity of work handled can be had from the following partial list of typical equipment which is shape-cut and welded in these shops: scrap winders, mine cars, truck bolsters, frames for roller tables, transfer cars, limestone cars, cooling beds, ingot mold cars, pack lifters, machinery bases, cat walks, pulpit stairways, and gear-reducing cases. Also cut to shape are many types of shaper dies and punch blocks, as well as a diversity of other products, such as liner plates for cement mills, pulverizer hammers and resilient wheels.

Advantages of Shape-Cutting

Without the shape-cutting process, it would be impossible to fabricate this equipment to present-day standards, and at the same time to do the work speedily and economically. This is because shape-cutting has a number of outstanding advantages over former fabricating methods. These are as follows:

Savings in Time.—Production is considerably speeded up by using rolled steel flame-cut to shape. There are no patterns to make, and often little or no machine work is necessary following cutting. Small-lot orders, such as motor frames or gear cases can be turned out in 50 per cent the former time required. Production of lift cams for roller tables provide another example of the time saved. Previously it took 16 hr. to machine one of these cams from a forging. Now, 5 cams can be flame-cut to approximate shape in 1 hr., with only 1 hr. additional per cam required for finish-machining. Total time per cam is about 1 hr. 15 min., as opposed to the former time of 16 hr.

Flexibility.—Flexibility is probably the outstanding advantage of shape-cutting. Practically any size and thickness of metal can be cut to any required shape. Material as thin as $^1/_{32}$ inch can be cut by stacking the sheets, and using the stack-cutting procedure; the majority of work in the fabricating shop, however, runs from $^1/_8$ to 12 inches in thickness. Even material over 12 inches and up to 18 inches and more in thickness is readily cut, using a water-cooled blowpipe. As to size, plates can be handled with stationary cutting machines up to 60 ft. in length and 48 inches in width. One of the longest jobs handled was an engine frame 42 ft. in length. Circles from $1^1/_2$ inches in diameter to 48 inches in diameter can be cut with the regular machine set-up. By setting the blowpipe stationary and using an auxiliary turntable for supporting the work, there is no limit to the diameters which can be cut. Examples of these larger diameters are blast furnace bell beams and bases for charging tracks. Furthermore, multiple-blowpipe set-ups can be used for the quantity production of small parts. In other words, the flexibility of oxyacetylene machine-cutting is such that there are practically no limits to the size and shape of material which can be cut.

Design.—Because of the versatility of shape-cutting, few restrictions are placed on the design engineer. Changes in specifications can be made up to the last minute before fabrication. Cutting-machine set-ups can be changed in a matter of minutes to take care of new or improved designs. Designers do not have to consider the possibility of a change-over in machine equipment when a redesign is called for. There is no necessity for scrapping expensive equipment, or for new capital outlay. Factors which formerly limited the full expression of the designers' ideas are therefore largely eliminated. In fact there are many desirable features of shape-cut and welded fabrication that can be obtained in no other way. Reinforcing ribs and gussets, for instance, can be placed in almost any position without fear of shrinkage cracks.

Savings in Weight.—Weight reduction with flame-cut and welded fabrication is achieved without sacrifice in strength. In many cases, the fabricated equipment, though lighter, is more efficiently designed to stand the ordinary stresses and strains encountered in service. For example, a bolster of rolled-steel construction for a 50-ton truck weighs 780 lb. as against 824 lb. for a cast steel bolster. In addition, the permanent set of the fabricated bolster is 50 per cent greater than that of the cast bolster.

Accuracy.—With accurately made templets, with the blowpipe held firmly, and with uniform and correct cutting speed, tolerances of cut edges can be kept within extremely narrow limits. Average tolerance for the general run of steel mill work is $^1/_{16}$ inch. However tolerances are often held to plus or minus $^1/_{32}$ inch, such as for breaker press rams fabricated out of 4- to 6-inch thick rolled steel. Machine-cut edges are frequently so smooth that it is difficult at times for those not familiar with the process to credit it with such high-quality workmanship. Usually no further machining is required.

Other Advantages.—Other advantages of shape-cutting include *lower investment, lower maintenance* and *less obsolescence*, than with most other machine tools. An-

* Presented at Annual Meeting, A. W. S., Oct. 1940, Cleveland, Ohio.
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other feature is that highly skilled mechanics are not necessary. Good *operators can be trained more quickly* than can machinists, for instance. Still another advantage is that there is *less scrap* with fabricated structures than with cast sections. Finally, rolled steel is *more easily* welded than cast steel.

Savings in Cost.—The net result of all these advantages is that there is a definite reduction in the cost of shape-cut and welded equipment, for savings in patterns, machine work, equipment investment and time are all reflected in over-all lower costs. For example, it is estimated that a scrap winder can be fabricated today from rolled steel at approximately one-half the cost of methods used ten years ago.

Shop Organization

Material under construction flows through the fabricating shop in an orderly and well-planned manner.

When blueprints are received for a certain piece of equipment, sketches are made from the drawings of each individual part which is to be shape-cut. From these sketches, the templet-maker then prepares the various templets required. A templet is usually constructed whether one part or 1000 parts are required, except where there are no irregular shapes or where circles are cut by means of mechanical tracing. More will be said later regarding the construction of templets.

The foreman in charge of the shape-cutting department supervises the flow of work during cutting. One operator and a helper usually handle two stationary cutting machines so that while one machine is cutting, work is being setup on the second machine. Also, where parts to be cut are sufficiently small so that two plates can be laid out on the cutting bed, tandem set-ups are used on a single machine. This, of course, requires two identical templets. While one cut is in progress, finished work is being removed and a second plate placed in position for cutting.

After the material has been cut to shape, the next operation, such as machining, grinding, bending or welding, is marked on the plate. Welding bevels are flame-cut, except where shapes are intricate or where it is necessary to machine J-grooves in heavy sections. The various parts are then assembled and welded, and the entire structure stress-relieved in a furnace.

All templets are kept permanently until the design of the particular part becomes obsolete. They are tagged with an aluminum stencil which bears the date and number of the drawing. In addition, each templet is indexed in a card file. Noted on the card for a particular templet are the order number, customer drawing number, templet number, size and thickness of stock, amount of linear inches cut, cutting speed, and the number of the cutting nozzle used. Also a small sketch of the part is made on the card. Where any machine work is required, this is also specified.

When an order is received, the card file is first checked to see if a similar part has been flame-cut previously. If so, the templet is rechecked for accuracy, then delivered to the cutting operator along with the file card containing the cutting data.

Shape-Cutting Equipment and Gas Supplies

Equipment in the fabricating shop for shape-cutting consists of four large stationary cutting machines and two smaller portable machines. In addition, a dozen or so hand-cutting outfits are in constant use for miscellaneous operations, such as for cutting rivets, angles and small simple shapes.

Oxygen and acetylene are piped to 12 welding and cutting stations located at various points throughout the shop. Acetylene is supplied from two 500-lb. generators, while oxygen is piped to the fabricating shop as well as to other parts of the mill.

It might be mentioned here that after comprehensive tests involving acetylene and other fuel gases, it has been proved conclusively that the use of acetylene results in faster, and more economical quality cutting.

Shape-Cutting Procedures

Before illustrating typical examples of steel mill equipment fabricated by shape-cutting and welding, it might be well to cover briefly a number of factors which affect the success and accuracy of the shape-cutting operation. These include templet construction, the cutting of alloy and high-carbon steels, heavy cutting, stack-cutting and multiple-blowpipe cutting.

Templet Construction.—In constructing templets for intricate shapes which must be cut to close tolerances, it is necessary to take expansion and contraction into consideration. This is especially true where it is necessary to hold internal and external dimensions to small limits. Experience resulting from cut-and-try methods is the usual guide in providing for expansion and contraction, but one simple example will serve to illustrate the principles involved. Suppose plate is to be cut in the shape of a doughnut with 12-inch I.D. and 18-inch O.D. The I.D. is cut first, and, as the metal heats, it expands. When the O.D. is then cut and the part cools and contracts, the final dimension of the O.D. will be found to be slightly less than the required 18 inches. Thus, in constructing the templets, it is necessary to make the diameter of the track for the O.D. $18^{1}/_{16}$ inches, rather than an exact 18 inches.

Alloy and High-Carbon Steels.—Alloy and high-carbon steels, where the carbon is over 0.45 per cent, should be preheated to from 800 to 1000° F. prior to cutting. This is done in a preheating furnace, or with a multi-flame heating head which traverses the surface to be cut just ahead of the cutting blowpipe. For heavier sections 1 inch in thickness and over, it is advisable to use two heating heads—one ahead and one just behind the cutting blowpipe. For steels with exceptionally high carbon content (0.70 or 0.80 per cent carbon), postheating should be applied along the face of the cut edge after cutting. The effect of these preheating and postheating treatments is to soften the flame-cut edge of the alloy or high-carbon steel, thus facilitating subsequent machining operations.

Heavy Cutting.—In order to obtain clean, accurate cuts in material over 12 inches in thickness, it is especially important that oxygen and acetylene pressures and cutting speeds be maintained uniformly at the required amounts. Even slight variations will result in ragged cuts, or possibly in losing the cut. Also, in cutting heavy sections, care must be taken not to get any "back-flow." This is the action of unburned oxygen which rebounds from flat surfaces below the work and strikes against the bottom of the kerf. The result is a "bell-mouth" effect at the bottom of the cut. If the oxygen pressure and cutting speed are properly coordinated, back flow is eliminated.

Stack-Cutting.—Stack-cutting is used for duplicating large quantities of parts such as cane knives, pulverizer hammers and disks for resilient wheels. Plate thicknesses vary from $^{1}/_{8}$ to $^{3}/_{4}$ inch, with the stack thickness from 1 to 3 inches. The limitation on stack-cutting is that the shape of the parts must be such that the plates can be clamped securely together. Hydraulic clamps, special lever clamps and ordinary C-clamps are used for this purpose. However, it should be stressed that

for good results it is essential that the plates be clamped in such a fashion that there is no likelihood of air pockets forming between the stacked plates. Also, it is important that oxygen and acetylene pressures be adjusted correctly for stack-cutting.

Multiple-Blowpipe Cutting.—Multiple-blowpipe cutting, employing two or more blowpipes, can be used on small parts where there is no shop vibration. For this type of work it is important that all controls are in exact adjustment.

Some Comments on Training Welders

By Donald P. Masterson*

MR. LAND's well written paper and his presentation of it at Cleveland aroused as much comment and heated discussion as any of the very interesting group.

Some of the points raised in the discussion of the paper were:

How long does it take to train a welder?
What can we expect of a welding school graduate?
Should we train mechanics to be welders or apprentice welders to be mechanics?
Is welding a trade or a tool to be used by the mechanics of the various trades?
What kind of a job are the welding schools doing? How can we assist them?

As these questions and the training program are of vital interest to the whole industry something besides "passing the buck" back and forth should be done about it. It appears improbable that either industry or the schools alone can do anything constructive about it. Together they can bring the welding training program to a high peak of efficiency.

The question should be settled once and for all that the welder is a skilled mechanic and not just a machine operator. I once asked the superintendent of a large plant, whose knowledge of welding I had every reason to respect, "How long does it take to train a welder?" He replied, "Fifteen years!" Probably his answer was colored and influenced by a bad day in the shop but most persons who have been active in the training of welders hold the opinion that the welding school graduate is an apprentice welder. How fast he will become an all-around welder depends on a number of things. The type of shop he is employed in; the opportunity he gets in that shop; his aptitude and adaptability; the guidance he receives in the shop and many other things will help determine the total time. Probably most authorities will agree that it takes as long to train an all-around welder as it does any other mechanic. An all around welder meaning one who can weld both with the electric arc and the acetylene torch; lay out and fit-up his own work and read the blue-prints necessary on the job. But how many industries are in need of a great number of welders of this type?

If you are turning out Class-1 pressure vessels do you care if your welding apprentice can carbon-arc weld 20-gage galvanized iron? If you are producing aircraft by gas welding do you care if your welders can weld heavy pipe with the arc?

Analyzing the welding needs of the various industries we will find that most of them are interested in specialized welding. Facing a period of peak production, as we do now, why isn't it possible to go into the school, select your prospective apprentice, and ask that he be given intense training along lines that will fit him for your use in the shortest time interval? The effect of this would be to give the student a goal near at hand and should prove a powerful incentive for rapid progress. After he takes his place in your organization see that he continues his training nights or Saturdays.

Types of Schools

Before any shop takes graduates of a welding school they should satisfy themselves (1st) of the type of training given and (2nd) the character of the school and the men running it.

Welding schools can probably be divided into two groups (1) public and (2) private. These can be again divided into good, bad and indifferent. The record of the private school has been anything but good. The high cost of welding instruction has led to a situation where some unscrupulous persons have charged the highest prices and given as little as possible in return. They hold out the promise of skill and proficiency and a job in a short period of time. Fortunately State Departments of Education are beginning to check on this type of "gyp joint." Better Business Bureaus can also help by warning prospective students.

This should not condemn the private schools that are undoubtedly doing a good job and once satisfied as to the honesty of this type of school their graduates should be given an equal chance with any others.

The public schools have installed a number of welding departments in the vocational and technical schools in the larger cities. Some are adequately equipped and the instructors are the best obtainable. In other places as many as twenty students may be registered in a class where the equipment might be said to be inadequate for six. The instructor sometimes may be a man whose welding knowledge is book acquired with little or no trade experience. If an Advisory Committee exists probably one of its most important functions should be the setting up of requirements necessary to teach a trade. The trade background of the teacher is far more important than his ability to use correct English. Courses in teacher training can smooth off the rough edges but cannot replace a lack of trade experience. The school can be no better than its instructors.

Courses of Instruction

The course of instruction should next come under close scrutiny. At the present time when we are all concerned over our ability to meet the demands of the Defence Program for speed the course should stick rather close to fundamentals although some time must be given to shop math., blue-print reading and theory.

The actual welding instruction should, above all else,

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be flexible. Different localities should specialize on types of training which will fit their students into the local industries. If aircraft is a major industry in your locality then train air-craft welders first, then if time permits, widen the instruction. If tank and boiler welding is being done on a large scale emphasize electric welding with large electrodes, etc.

The standards held to in the quality of welds produced by students is of major importance. No weld should be accepted that is not of good quality, acceptable to industry. Of course, some lee-way must be given the beginner in the looks of his first welds but as he progresses he must be made to realize that quality of weld metal and properly formed welds go hand in hand. No opportunity should be lost to check the work of the student, point out the defects and suggest the probable causes.

Obtaining a sufficient supply of materials for instruction purposes is often one of the biggest headaches the instructor has. Some large companies cooperate by saving their scrap metals for the school and the Board of Education truck picks up the scrap and returns it after it is used.

The Advisory Committee can assist the Instructor in many ways. Recommendations to the Board of Education or school authorities as to additional equipment or replacements of worn out equipment carry a lot more weight coming from industry than they do from the instructor. Mr. Land mentions modern equipment for school shops as being absolutely necessary, but the average instructor feels sure that the Board of Education believes that school equipment never wears out. A fact, often lost sight of, is that school tools and equipment are in the hands of novices at all times and, for this reason, receive harder use than in industry. The equipment at Edison Technical and Industrial High School is working over one hundred and ten hours a week. If forty hours is used as an average week this equipment is doing ten years work in four.

Age of Student

The age of persons being trained seems to have some bearing on his chances of becoming skilled. The high school student does not seem to profit by welding instruction before the age of sixteen. Probably we will see the day when the technical school will carry on two years beyond high school. This would give us a group in training between the ages of 17 and 20.

At the other end of the scale men over 45 years of age seem much slower, as a rule, to learn manipulative skills. Physical defects, often unnoticable, are sometimes responsible.

The selection of young men for training is an ideal that the instructor in the public school often thinks of but seldom has any chance to do much about. The public school, being a democratic institution, has to follow the policy of first come, first served. Once an individual is in the class it takes a hard hearted instructor to suggest to someone who is giving up his time to learn a trade that he is unable to profit by the instruction. Too many times he is left in the class and never becomes sufficiently skilled to obtain employment.

When we stop to realize that welding as an industrial tool is only about thirty-five years old and has been taught in the engineering and technical schools only for the last fifteen years we still have a lot of pioneering to do. The schools are only too anxious to meet the demands of industry and more than willing to accept any suggestions a trade committee might make.

The Employment Office and the School

It often happens that an industry is in the midst of a production rush that makes it necessary to increase the working force. Probably the school will be called on to furnish a number of men Of course the news spreads like wildfire that——Co. is employing welders. Then you find the rank and file of all welding classes bombarding the employment office of——Co. with requests for jobs. It does not matter how little training they may have had or how difficult the job may be they will try to "get by." In some cases where the foreman is desperate for help they are hired. Ninety-nine times out of a hundred they are unable to do the work and the foreman blames the school. From that time on you cannot get him to give a graduate of that school a hance. If the school is to be known by its product, the least the employment office can do is to give the school a chance to pass on the desirability of an individual and the amount of training he has had before time and money are wasted in hiring them. Any instructor, thrown in contact with a student for a period of time, gets to know a great deal about him; far more than the employment office can in a short interview. If they are lazy, careless, irregular in attendance or quarrelsome you will find that the transition from school to industry won't change them. Industry can definitely cut labor turnover if they will give the schools an opportunity to say whether a boy or young man has the proper characteristics and the training for the job.

Industry and the school should set up a testing program designed to fit the graduate into the local picture. Any welding superintendent is going to place more confidence in an affidavit that John Jones has passed vertical and overhead tests on $^3/_8$-inch plate with 70,000 pounds per square inch tensile strength and a ninety degree bend than he is that John has welded two hundred hours.

Welders coming into a town could be sent to a school to pass standard tests before looking for employment. This would cut down the number of drifters who are not qualified and who only waste the time of the employment division and the shop for testing. A few years ago one of the night school classes at Edison was restricted to steamfitters learning to weld pipe. After about six hours instruction one of the men asked for a template for a sixteen inch pipe tee. Questioning him the instructor found that the student's employer had an overhead tee joint to be welded and the student was going to do the welding. Trying to discourage him had no effect and he did the job. It took him about three hours to cut, fit and weld the joint with gas. It took an experienced welder about fifteen hours to undo what he did. Imagine our suprise when we heard that the student's employer was blaming the school for the failure! Putting the case before the Master Plumbers and the Steamfitters Unions it was decided that no member of the union could go on a pipe welding job without first passing a test before a committee made up of a member of the Master Plumbers Union, a member of the Steamfitters Union and the school instructor.

Welding has been, to a certain extent, retarded in its growth by a lack of technical knowledge. Now that this knowledge has crept abreast of the practical application we stand on the threshold of general acceptance of welding as the best method of joining metals. It is of vital importance that we see to it that all the welds made are of good commercial quality; and that there are trained welders available to do the vast quantity of work that faces the industry. Let the schools and industry cooperate in a training program which will enable both to realize their ambitions of better welds by better welders.

Recommended Procedure to Be Followed in Preparing for

WELDING OR CUTTING CERTAIN TYPES OF CONTAINERS WHICH HAVE HELD COMBUSTIBLES

I—INTRODUCTION

Severe explosions and fires may result if welding or other hot work is done on containers that may not be entirely free of combustible solids, liquids, vapors, dusts and gases. Containers of this kind can be made safe for such work at low cost but the necessary steps and precautions must be rigidly followed.

The practices recommended herein are equally desirable where any such container is to be subjected to any type of hot work or any operation that might create a spark or flame.

II—SCOPE

These recommendations are intended to apply to the preparation for welding and/or cutting of metal containers which have held flammable solids, liquids or gases, or substances which may produce flammable vapors or gases.

When in doubt as to whether a known substance is combustible and soluble in water, consult a *recognized* chemical reference book. If the properties of the substance previously held by the container are not known, they must be assumed to be flammable and insoluble in water.

Flammable and explosive substances may be present in the container from the following sources:

a. The container may have contained gasoline, light oil or some other type of volatile liquid that releases vapors at atmospheric pressure.

b. Hydrogen may be present if the container is metal and has contained acid, as the action of acid on metal may produce hydrogen.

c. If the container has held a non-volatile oil or a solid which at ordinary temperatures will release no vapors, flammable vapors may be produced when the container is exposed to heat. Vapors may be generated inside such a container, if there are deposits of sludge or scale present and the container is heated with a welding or cutting torch.

d. An explosive condition may exist if the container has held a combustible solid and finely divided particles of this matter are present in the form of a dust cloud.

These recommendations do not apply to the following classes of containers:

a. Containers when entered by workmen for cleansing from inside.

b. Tanks, bunkers or compartments on board ship.

(NOTE: The cleaning and gas freeing of cargo tanks are presented briefly in "A Manual for the Safe Handling of Inflammable and Combustible Liquids," dated April 1, 1938, issued by the Bureau of Marine Inspection and Navigation, U. S. Department of Commerce, Washington, D. C.)

c. Outside aboveground, vertical petroleum storage tanks.

(Note: Covered by a "Manual on Cleaning Petroleum Storage Tanks" published by the American Petroleum Institute, Department of Accident Prevention, 50 West 50th St., New York, N. Y.)

d. Gasometers or Gas Holders for natural and manufactured gas.

(NOTE: Before attempting to weld or perform other hot work on gas holders consult the American Gas Association, 420 Lexington Ave., New York, N. Y.)

e. Compressed gas cylinders.

f. Containers that have held nitrocellulose or pyroxylin solutions.

(NOTE: If welding, cutting or other hot work must be performed on such containers the manufacturer or supplier of the solutions should be consulted as to proper methods of cleansing. It must be remembered that inert gas is not effective in preventing or extinguishing a fire in this kind of material because the material itself contains sufficient oxygen to support combustion.)

III—GENERAL PRECAUTIONS*

1. If the container has held a toxic gas or substance that may result in a toxic gas being formed during the cleansing and purging operations, appropriate steps must be taken to protect the operator against harmful exposure.

2. Cleaning should preferably be done in the open; if in a building the room should be well ventilated so that flammable vapors will be quickly or by the steam method described herein. Examples of such containers are gasoline tank trucks, gasoline ground tanks, domestic heating fuel tanks and similar vessels that have contained oils or gasoline which are not

* Supplemental references. (1) "Handling, Cleaning and Filling Drums and Barrels," Industrial Safety Series—Petroleum No. 8—published by the National Safety Council, 20 North Wacker Drive, Chicago, Ill. (2) "Removing Flammable Vapors from Service Station Gasoline Storage Tanks," Industrial Data Sheet D—Petroleum No. 1—published by the National Safety Council. (3) "Regulation of the National Board of Fire Underwriters for Carbon Dioxide Fire Extinguishing Systems and Inert Gas for Fire and Explosive Prevention" as recommended by the National Fire Protection Association, published by the National Board of Fire Underwriters, 85 John Street, New York, N. Y.

be produced when the container is exposed to heat. Vapors may

of the National Board of Fire Underwriters for Carbon Dioxide Fire Extinguishing Systems and Inert Gas for Fire and Explosive Prevention" as recommended by the National Fire Protection Association, published by the National Board of Fire Underwriters, 85 John Street, New York, N. Y.

room should be well ventilated so that flammable vapors will be quickly and safely carried away.

(NOTE: The vapors of most flammable liquids are heavier than air and tend to collect on the floor, in pits or other low spots.)

3. All sources of ignition, such as open flames, unapproved light or power switches and unguarded electric lights should be removed from the vicinity of the container, or rendered inoperative.

4. The container, including all internal piping, traps and standpipes, should be emptied and drained thoroughly to remove as much of the contents as possible. Removal of sludge and sediment may be facilitated by scraping or, in some cases, by rotating the container with a *brass* chain used as a scrubber. Hammering with a *wooden* mallet may help to loosen scale. Iron or steel chisels, scrapers or hammers should not be used because of the danger of sparks igniting flammable vapors. (Spark-proof tools, manufactured especially for this type of work, are commercially available.) The residue should be immediately and safely disposed of so it will not increase the hazard of the work.

5. Containers divided into two or more compartments should have each compartment treated in the same manner regardless of what portion of the container is to be subjected to the welding or cutting process.

6. Welding of containers should be attempted only by experienced welding operators, and under the direct supervision of some person familiar with the explosive characteristics of the contents.

7. When welding or cutting keep the head and arms away from the head of the container as far as possible. Repair leaks on the sides of the container before repairing the head.

8. All cleaned containers which can be readily moved about from place to place with the possibility of becoming confused with a like piece of equipment which has not been cleaned should be stencilled "Safe (for whatever the character of work may be)" immediately after being prepared, with the date of preparation.

IV—INITIAL TREATMENT

The initial step in preparing a container generally depends upon whether the substance that it previously contained is readily water soluble. Where the substance is known to be readily soluble in water it can be removed by completely filling the container with water and draining several times. For example, an acid may be handled in this manner and the hazard of hydrogen produced by acid and metal eliminated. Care must be taken that the flushing is thorough so that all traces of the acid are removed as dilute acid frequently reacts with metal to produce hydrogen when concentrated acid will not. Examples of other water soluble compounds, which are readily removed by filling with water and draining the container, are acetone and alcohol.

Where the substance originally in the container is not readily water soluble the container must be treated by the hot chemical solution method or by the steam method described herein. Examples of such containers are gasoline tank trucks, gasoline ground tanks, domestic heating fuel tanks and similar vessels that have contained oils or gasoline which are not entered by workmen—usually less than 2000 gallons capacity.

It must be understood that the cleansing of a vessel is necessary in all cases and should be supplemented by filling the container with water prior to and during the hot repair work or by the use of an inert gas.

V—HOT CHEMICALS SOLUTION METHOD OF CLEANSING

1. The chemicals generally used in this method are compounds of sodium silicate or tri-sodium phosphate (strong washing powder) dissolved in water to a concentration of from two (2) to four (4) ounces of chemical per gallon of fresh water.

2. Close all openings in container with exception of drain and filling connection or vent. Damp asbestos, wood flour or similar material may be used for sealing cracks or other damaged sections to be repaired.

3. Fill container with water to overflowing and flush thoroughly, preferably admitting water through the drain connection. If no drain is provided, flush by inserting hose through filling connection or vent, leading hose to bottom of container to secure agitation from bottom upward, thus causing any remaining liquid, scum or sludge in the container to be carried upward and discharged by overflowing.

4. Thoroughly drain container.

5. Completely dissolve the amount of chemical required by size of container in small quantities of boiling water and pour into the container. Then fill container with fresh water.

6. Make steam connection to the container either through drain connection or by pipe entering through filling connection or vent and leading to bottom of container. Admit steam into the chemical solution and maintain solution at a temperature of 170 to 190° F. At intervals during the steaming, add sufficient water to allow discharge by overflowing of any volatile liquid, scum or sludge, that may have collected at the top. Continue steaming until no appreciable amount of volatile liquid, scum or sludge appears at the top of the container.

7. Drain container.

8. After draining, a sample of gas from the container should be obtained and tested. Use a combustible gas indicator and detector of which there are several well known makes commercially obtainable or the gas sampler apparatus and procedure described in Appendix "A" of this report.

9. If steaming facilities for heating the chemical solution are not available, a less effective method is the use of a cold-water solution with the amount of cleansing compound increased to about six (6) ounces per gallon of water.

10. In performing cleaning operations by this method, personnel should guard against injury from steam or caustic cleansing compound. Workmen should provide themselves with suitable gloves and other protective coverings.

VI—STEAMING METHOD OF CLEANSING

1. Prior to steaming, fill the container at least twenty-five per cent full with hot soda or soda ash solution (1 lb. of caustic to a gallon of water) and agitate it sufficiently to insure that the interior surfaces are thoroughly flushed.

2. Thoroughly drain the container.

3. Close all openings in the container with the exception of drain and filling connection or vent. Damp asbestos, wood flour or similar material may be used for sealing cracks or other damaged sections to be repaired.

4. Blow live steam into the container through drain, preferably, or any accessible opening for a period of time to be governed by the condition or nature of the flammable substance previously contained. When a container has only one opening it must be positioned so that condensate will drain from the same opening into which the steam nozzle is inserted.

(NOTE: When steam or hot water is used to clean a container, the operator should wear suitable clothing, such as boots, hood, etc., to protect himself against burns.)

5. Low pressure steam should be used. The steam line into the container should be steam hose of not less than $^3/_4$ inch diameter, without nozzle or valve at the outlet end. The steam pressure should be controlled by valve ahead of the hose.

(NOTE: If metal nozzle is used it should be of non-sparking material. It should also be electrically grounded to the container and the container should be grounded to prevent static electricity accumulation.)

6. The time of steaming should be continued until the container is free from odors and the metal parts of the container are hot enough to permit steam vapors to flow freely out of the container vent or similar opening. It is inadvisable to set a definite time for steaming containers, even of specific size, as weather conditions, such as rain or extreme cold, may condense the steam vapor as fast as it is introduced. It may take several hours to heat up the container to such a temperature that steam vapor will flow freely from the outlet of the tank.

7. Thoroughly flush the inside of the container with boiling water and drain.

8. Inspect the inside of the container to determine that it is clean. This may be done by using a mirror to reflect light into the vessel. If examination shows that the container is not clean, it should again be steamed and flushed with hot water.

(NOTE: Light source should be an electric lantern or flashlight approved for use in locations where flammable vapors are present.)

9. Inspect the container to determine if it is gas free. This test preferably should be made with one of the several good makes of gas indicators and detectors commercially obtainable. If unavailable, take a sample of the gas from the container with the Larner Gas Sampler as described and test it for flammability as described in Appendix "A."

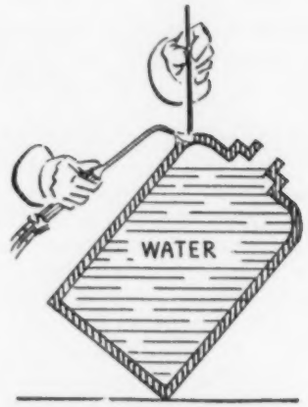

Fig. 1—Containers Which Have Contained Flammable Materials Should Be Filled with Water Before Welding or Cutting. Make Sure the Space Above the Water Level Is Vented

VII—WATER FILLING TREATMENT

Where water is to be used to supplement one of the methods of cleansing described herein, and it is highly desirable to do so, position the container so that it can be kept filled with water to within a few inches of the point where welding or cutting is to be done. In doing this care should be taken to make sure that there is a vent or opening to provide for the release of heated air from inside the container. This can usually be done by opening a bung, hand-hole, or other fitting above the water level.

VIII—INERT GAS TREATMENT

This treatment is based on the fact that flammable gases and vapors will be rendered non-flammable and non-explosive if mixed with a sufficient amount of an inert gas.

Where an inert gas is used to render a container in which flammable gases and vapors are present safe for welding, cutting or other hot work, the individual in direct charge of the work must be thoroughly informed. He must know the percentage of inert gas that must be present and how to produce and maintain this percentage until the work is finished. Attempting such work without proper knowledge or equipment is dangerous.

Permissible inert gases include carbon dioxide and nitrogen. Carbon dioxide is generally available; it is heavier than air and will tend to remain in containers having top openings during welding or cutting operations.

Nitrogen is applied in the same way as carbon dioxide supplied in

the gas from the container with the Larner Gas Sampler as described and test it for flammability as described in Appendix "A."

Permissible inert gases include carbon dioxide and nitrogen. Carbon dioxide is generally available; it is heavier than air and will tend to remain in containers having top openings during welding or cutting operations.

Nitrogen is applied in the same way as carbon dioxide supplied in cylinders but the volume used and percentage concentration maintained must be at least 10% more than for carbon dioxide.

Procedure

1. Close all openings with exception of drain and vent. Damp asbestos, wood flour, adhesive tape, friction tape or similar material may be used for plugging cracks or other damaged sections.

2. Fill container with water to overflowing and flush thoroughly, preferably admitting water through the drain. If no drain is provided, flush by running hose through vent to bottom of container to secure agitation from bottom upward.

3. Position container when possible so that portion to be worked on is uppermost.

4. Drain off water allowing as much as welding or cutting work permits to remain in the container and thus reduce volume of inert gas required.

5. Introduce a sufficient quantity of carbon dioxide into the container to produce a concentration of not less than 50 per cent by volume. This will usually require the introduction of a volume of inert gas at least as great as the volume of the gas space in the container since the inert gas may tend to flow directly out of the vent after displacing only part of the previously contained gases or vapors.

(NOTE: When the carbon dioxide content is not less than 50 per cent, any mixture, regardless of ratio of flammable vapor to air, will be non-flammable and non-explosive, unless the flammable vapor is principally hydrogen or carbon monoxide in which case a minimum of 80 per cent carbon dioxide content is required.)

It is permissible to use carbon dioxide gas compressed into cylinders or solidified carbon dioxide, commonly called "Dry Ice," handled commercially in cakes 10 x 10 x 10 inches, weighing 50 pounds.

a. Introduction of carbon dioxide gas from cylinders (see Fig. 2):

Introduce carbon dioxide into container at low pressure, preferably replacing water. As water leaves drain, introduce equal volume of carbon dioxide through vent.

Where both vent and drain are not present, introduce carbon dioxide through hose with outlet at bottom of tank so that heavier carbon dioxide forces other gases above it out of vent.

(NOTE: Calculate volume of container and introduce at least equal volume of carbon dioxide. To estimate volume of carbon dioxide withdrawn from cylinder, weigh cylinder before and after withdrawing gas and calculate volume withdrawn on basis of 8.7 cubic feet per pound. If nitrogen is used, estimate volume withdrawn from cylinder by weighing cylinder before and after withdrawing gas and calculate volume withdrawn on basis of 13.8 cubic feet per pound.)

b. Introduction of carbon dioxide as solid:

Crush the solid and shovel sufficient into container to produce volume of carbon dioxide gas to fill gas space. The solid should be evenly distributed over the greatest possible area to secure rapid formation of gas.

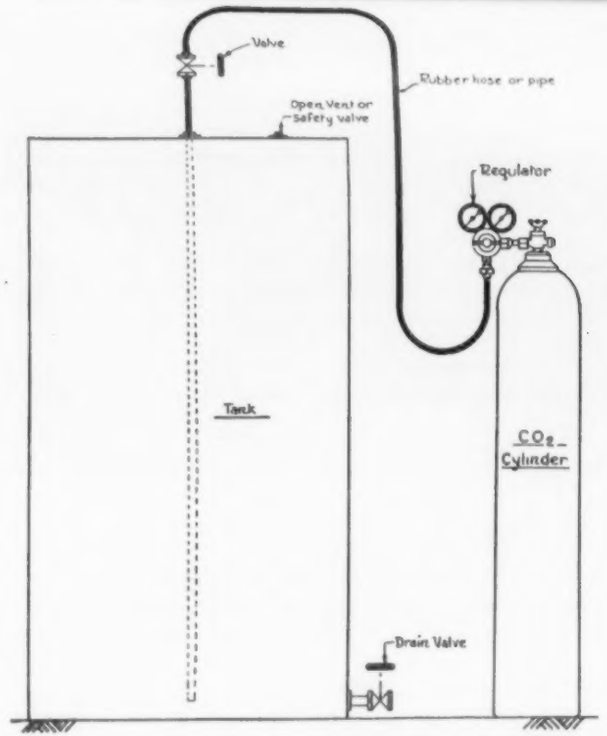

Fig. 2—Method of Introducing Carbon Dioxide Gas from Cylinders. (Note: When Large Volume of Carbon Dioxide Is Required, the Rate of Withdrawal of the Gas from the Cylinder Can be Increased Without Freezing the Cylinder Valve by Inverting the Cylinder. If Nitrogen Is Used, Cylinders Should Be Used Upright.)

(NOTE: One pound solid carbon dioxide will produce 8.7 cubic feet of carbon dioxide gas at 70° F. at atmospheric pressure Introduce sufficient weight of solid carbon dioxide to provide a volume of gas at least equal to calculated volume of container.)

6. Determine by either method (*a*) or (*b*) whether sufficient carbon dioxide is present to render contents of container non-explosive. Take samples from bottom and top of container.

(*a*) Analyze samples chemically for carbon dioxide by means of Orsat or other approved gas analysis apparatus. Concentration of carbon

dioxide found should be not less than 50 per cent by volume in every sample. (See Note following Rule 5 on page 9.)

(*b*) Use the gas sampler illustrated and the procedure described in Appendix "A." At safe distance from container, test the sample for flammability by releasing small volume and exposing to flame.

7. Take steps to maintain high carbon dioxide concentration during the entire hot work operation by one of the following two methods:

(*a*) If carbon dioxide is supplied from cylinders, continue to pass the gas at low pressure into container during welding or cutting operation.

(*b*) If carbon dioxide is supplied in solid form, dump excess solid into container where it will vaporize during welding or cutting operation.

(NOTE: Avoid bodily contact with solid carbon dioxide. It will produce "burns." Avoid breathing large amounts of carbon dioxide. Do not tightly close a vessel which contains solid carbon dioxide as such will produce pressure.)

8. Proceed with welding or cutting operation or other hot repair work. At frequent intervals make sure that carbon dioxide concentration is sufficiently high, following Paragraphs 6 and 7 above.

APPENDIX "A"

Gas Sampler

Description of necessary material, operation of and test of flammable and explosive gases with gas sampler apparatus:

Material Required (see Fig. 3)

(A) Football bladder or small rubber bag.

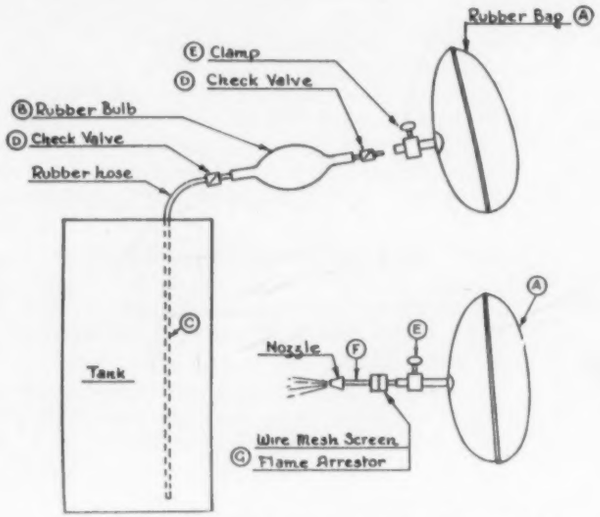

Fig. 3—Apparatus for Obtaining and Testing Samples of Flammable or Explosive Gases

(B) Rubber bulb pump (hand squeeze type).

(C) Rubber tubing ($^1/_4$ to $^3/_8$-in. internal diameter).

(D) Ball type check valves (rubber tube type, two (2) necessary).

(NOTE: A rubber syringe equipped with check valves can usually be procured at any drug store. This will serve the purpose of the rubber bulb pump and will eliminate the check valves as separate items.)

(E) Rubber tubing clamp.

(F) Nozzle (metal construction, similar to glass-tube eye dropper).

(G) Wire mesh flame arrester (100-mesh wire cloth, 0.0045-in. wire diameter, 0.0055-in. openings).

Operation of Gas Sampler (see Fig. 3)

1. Install check valves in rubber bulb (B) so that one valve allows air to suck into bulb and the other valve allows air to discharge from the bulb when the bulb is operated by squeezing and releasing with the hand. Connect the suction end of rubber bulb (B) to rubber tubing (C).

2. Lower free end of rubber tubing (C) into container to the level at which the sample of gas is desired.

3. Operate rubber bulb pump (B) (squeeze and release by hand) a sufficient number of times to insure that all entrapped air is discharged and that these parts of the sampler apparatus are completely filled with gas representative of that in container.

4. Thoroughly deflate rubber bladder (A) and connect the filling tube of same to the discharge end of the rubber bulb pump (B).

5. Operate rubber bulb pump (B), fill and expand the rubber bladder (A) to a pressure sufficient to conduct test of the gas.

6. Seal rubber bladder (A) with clamp (E) and disconnect same from other parts of the sampler apparatus.

7. Connect nozzle (F) and flame arrester (G) to rubber bladder (A).

Test of the Gas

At safe distance from the container, apply flame of match, candle or torch to the tip of nozzle (F), and simultaneously release clamp (E) allowing gas to flow from the tip of the nozzle. If the flow of gas from the nozzle has a tendency to deflect or blow out the flame, the gas may be considered to be non-flammable and non-explosive and the contents of gas in the container sufficiently safe for accomplishing welding or other hot mechanical work.

If, however, the flow of gas from the nozzle has a tendency to ignite or flash-back explosions occur, it *must* be considered that the gas content of the container is flammable, explosive and *unsafe* for performing any welding or other hot mechanical work on the container.

Capacitive Stored Energy Systems of Spot Welding*

By Howell B. Axtell† and R. L. Ringer, Jr.†

IT has been recognized for years that it is possible to join two or more pieces of various metals in any thickness within limits by spot welding. Briefly, this process requires the passing of an electric current through a localized area of the pieces by means of suitable electrodes, which not only carry the current to the work but also exert enough pressure to forge the pieces together at the points which have been sufficiently heated by the current.

Various combinations of materials require different values of current, pressure and time in order to secure the most satisfactory welds. In the case of most ferrous materials, the electrical resistance is high enough and thermal conductivity low enough that they may be raised to welding temperature by a relatively small current, compared to that required in the case of the higher conductivity materials. It is also true that ferrous materials have a much wider plastic range, between the solid and the molten phases, in which they may be forged or welded together, than have many of the high-conductivity materials. As a result of these differences, there has been much difficulty in the past in securing sound, strong welds in such materials as, for example, 24 ST Alclad aluminum alloy, which is being used so widely today in the fast-growing aircraft industry. For this reason it has been necessary to develop equipment especially suited to the welding of these materials; equipment which retains the fundamental requirements of current, pressure and time control, but secures them in a novel manner, which lends itself to the making of superior welds in these alloys.

One of the great drawbacks to the welding of the aluminum alloys has been their high conductivity, both thermal and electrical, which has required, in 60-cycle welding practice, the use of quite high currents to raise the material to the welding temperature. Heating is proportional to I^2RT, in which I is secondary current, R resistance of the work, and T time. But when thermal conductivity is high so that heat tends to flow away readily and rapidly from the welding spot it is desirable to minimize T so as to minimize this loss of heat. And with low R a characteristic of the material, we have to use a large value of current in order to secure adequate heat for welding. This results in a heavy line demand on a single phase of the power line which energizes the primary of the welding transformer: not only a heavy demand, but one of low lagging power factor and of low load factor. On account of the narrow plastic range, the aluminum alloys also require a very accurately controlled welding current.

In addition to the electrical drawbacks to the welding of these aluminum alloys on standard, 60-cycle welding equipment, there have been found mechanical disadvantages which have resulted in failure to produce welds that are free from internal shrinkage cracks and voids. The equipment to be described has been so designed as to minimize these difficulties, and has proved itself able to produce sound, crack-free welds of superior physical qualities in the aluminum alloys with low power demand, taking 3-phase energy at approximately unity power factor from a power line, and operating at a very favorable load factor. Other advantages, such as low maintenance costs and reduction of tip pick-up or alloying of aluminum and copper at the tips, will be discussed later.

Fundamentally, the "Hi-Wave" system of welding stores energy in a capacitor bank, drawing it from a single- or three-phase power line over a relatively long period of time and then discharging it in a short time through the primary of a welding transformer, the secondary winding of which is connected to the welding electrodes. The amount of energy stored in the bank is equal to $^1/_2\ CE^2$; that is, it is proportional to the capacitance of the bank and to the square of the voltage to which the capacitor is charged. The total energy used in making the weld is, of course, equal to the charge in the capacitor, less losses in the electric and magnetic circuits. The wave form of the discharge, both its amplitude and its slope, depends on the amount of energy and upon the electrical constants of the circuit: resistance, inductance and capacitance. Thus, by properly adjusting these constants to suit our material, we are able to obtain accurately and repeatedly the exact wave form and timing of energy to make uniformly satisfactory welds.

Theoretically, the circuit of the capacitive stored energy welder resolves itself into the following (Fig. 1):

C = capacity in Farads of capacitor bank.
R_1 = external resistance in primary circuit.
R_2 = external resistance in secondary circuit.
R_p = resistance of primary winding.
R_s = resistance of secondary winding.
L_1 = external inductance in primary circuit.
L_2 = external inductance in secondary.
L_p = self inductance of primary winding.
L_s = self inductance of secondary winding.
e = the instantaneous voltage across condenser C.
E = the maximum or initial value of e.
i_1 = the instantaneous value of primary current.
i_2 = the instantaneous value of secondary current.

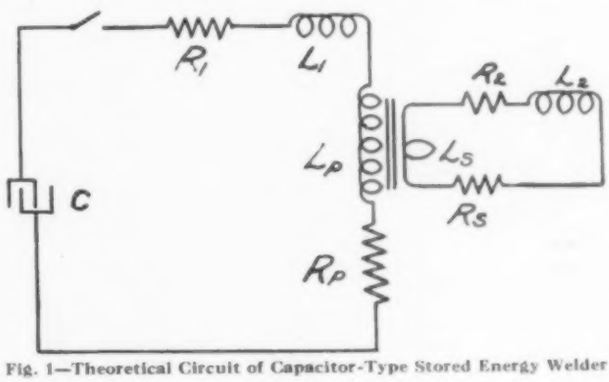

Fig. 1—Theoretical Circuit of Capacitor-Type Stored Energy Welder

* Presented at Annual Meeting, A. W. S., Cleveland, Ohio, October 1940.
† The Taylor-Winfield Corporation, Experimental Department, Warren, Ohio.

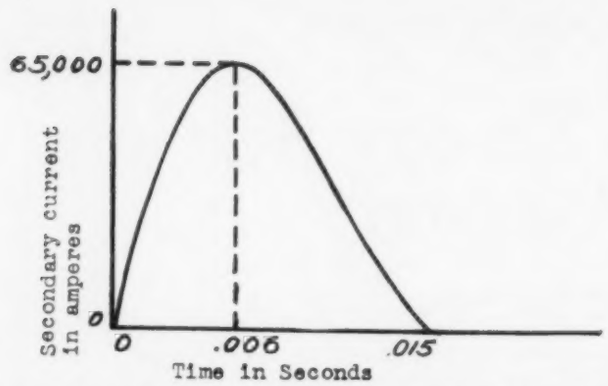

Fig. 2—Desired "Ideal" Secondary Current Wave for Welding Some Given Material

I_1 = maximum value of i_1.
I_2 = maximum value of i_2.
t = time in seconds, measured from t_0, the start of the discharge.

The general circuit equations are

$$L\frac{di_1^2}{dt^2} + R\frac{di_1}{dt} + \frac{i_1}{c} = 0,\ i_1 = C\frac{de}{dt}$$

where $L = a^2L_2$ = inductance in series with C if $L_1 = 0$ and we have an "ideal" transformer.
$R = a^2R_2$ = resistance under same conditions as L.
a = turns ratio of transformer = N_p/N_s.

These equations reduce to the following forms, in which

$$Z = \sqrt{\frac{R^2}{4} - \frac{L}{C}}$$

$$i_t = -\frac{E}{Z}\epsilon^{-Rt/2L}\sinh\frac{Zt}{L}$$

$$e = E\epsilon^{-Rt/2L}\left(\frac{R}{2Z}\sinh\frac{Zt}{L} + \cosh\frac{Zt}{L}\right)$$

It will be recognized that there are three possible variations of these equations:

Case I, where $R^2/4 > L/C$.
Case II, where $R^2/4 < L/C$.
Case III, where $R^2/4 = L/C$.

In actual practice, case II has been the condition used.

Here Z is imaginary and $\sqrt{\frac{R^2}{4} - \frac{L}{C}} = \left(\sqrt{-1}\right)\left(\sqrt{\frac{L}{C} - \frac{R^2}{4}}\right)$. Considering that $\sinh jx = j\sin x$, $\cosh jx = \cos x$, $\tanh jx = j\tan x$, we may write using $Z' = \sqrt{\frac{L}{C} - \frac{R^2}{4}}$

$$i_1 = -\frac{E}{Z'}\epsilon^{-Rt/2L}\sin\frac{Z't}{L}$$

$$e = E\epsilon^{-Rt/2L}\left(\frac{R}{2Z'}\sin\frac{Z't}{L} + \cos\frac{Z't}{L}\right)$$

For purpose of equipment design, it has been possible to work out expressions based upon mathematical relationships which greatly simplify the calculation of the circuit constants necessary to secure any particular desired wave form.

Let us assume that we want to weld two pieces of material which previous experience indicates may be welded with a secondary current of approximately the wave shape shown in Fig. 2:

We shall compute the machine settings necessary to obtain this current at throat depths of 16 and 30 inches, with the condenser voltage limited to 2850 volts.

For the 16-inch machine, assume the following 60-cycle constants:

$L_2 = 0.055 \times 10^{-5}$ Henrys
$R_2 = 7.45 \times 10^{-5}$ Ohms

Since the time required for the first "half cycle" of the discharge is 0.015 second, the approximate frequency is $1/(2 \times 0.015)$ or 31 cycles per second. At this frequency, the effective resistance is only possibly 85% of the 60-cycle resistance.

$R_{2\ eff.} = 0.85 \times 7.45 \times 10^{-5} = 6.34 \times 10^{-5}$ Ohms

By application of the design formulas referred to above, we get

Capacitance 595 Microfarads
Turns ratio 260

and a wave form as shown in Fig. 3:

For the 30-inch machine,

$L_2 = 0.096 \times 10^{-5}$ Henrys
$R_2 = 9.29 \times 10^{-5}$ Ohms
Capacitance 860 Microfarads
Turns ratio 167

and the secondary current will be as shown in Fig. 4.

The physical difference between these two machines is

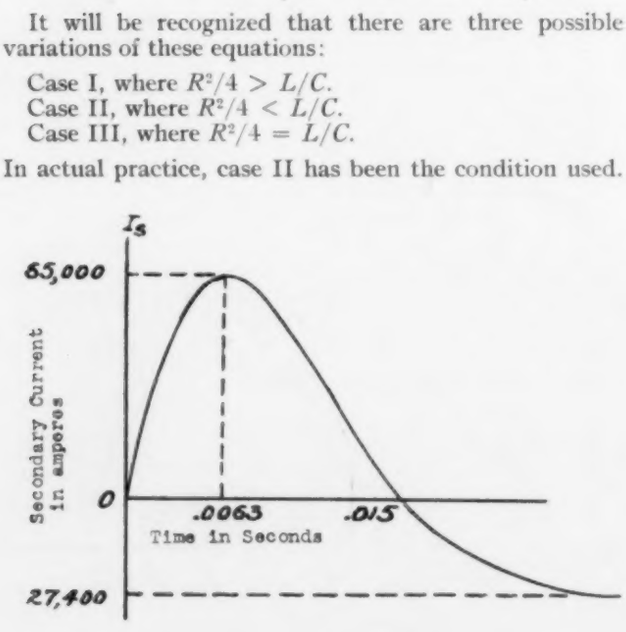

Fig. 3—Secondary Current Wave for Welding Machine with 16-Inch Throat Depth, Using Turns Ratio 260, Capacitance = 595 MFD., Charged to 2850 Volts

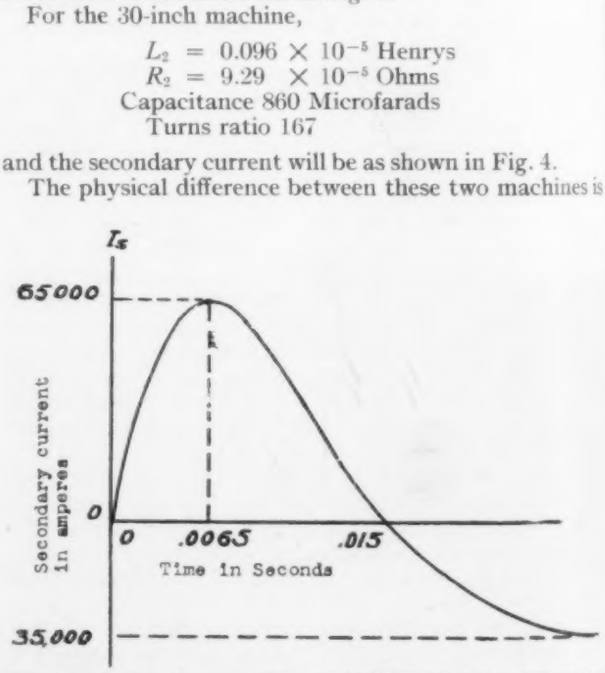

Fig. 4—Secondary Current Wave for Welding Machine with 30-Inch Throat Depth, Using Turns Ratio = 167, Capacitance = 860 MFD., Charged to 2850 Volts. The Same Wave Would Be Obtained in This 30-Inch Machine by Using Turns Ratio = 196, Capacitance = 595 MFD., Charged to 3395 Volts

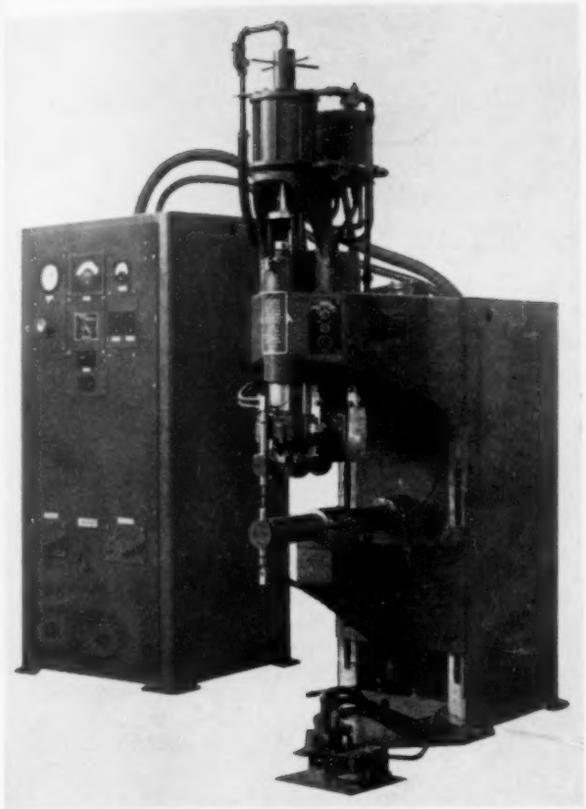

Fig. 5—Complete Capacitive Stored Energy System for Spot Welding Aluminum

only the throat depth. The resistance of the work is the same in either case, so the increase in secondary resistance is due to the increased length of conductors in the deeper throat.

The increased capacitance represents the increase in energy required to produce the desired secondary current in the higher-resistance 30-inch-throat machine. This increased energy could also have been obtained by increasing the charge on the 595 Mfd. condenser from 2850 to 3395 volts, though this is higher than the maximum voltage we assumed for our example. However, using the 3395-volt charge on 595 Mfd. capacitor and a turns ratio of 196, we again get a wave form exactly the same as that shown in Fig. 4 for this machine.

The above computations are merely an example showing the flexibility of this system and do not necessarily represent values suitable for any actual combination of materials.

Equipment especially suited to the welding of aluminum alloys was designed from such figures; which in general appearance is very much like a standard press welder but incorporates several special features to fulfil the requirements of sound uniform welds in such materials. Figure 5 illustrates a complete aluminum welding installation of this type.

Since aluminum has a high coefficient of thermal conductivity and no appreciable plastic range, it is necessary to provide energy at a high rate, maintain pressure throughout the entire welding period and minimize surface heating to obtain sound welds. Uniform welds require that the same amount of energy be dissipated in the material at the same rate in each succeeding operation.

In order to provide energy at a high rate the capacitor is discharged through a suitable transformer into the work. The welding impulse so obtained is accurately controlled by a variable combination of capacitance, voltage and turns ratio. By this means the weld is made by a single surge of substantially unidirectional current which may be as high as 100,000 amperes in as short a time as 0.002 second. Since all of the elements of the welding circuit are constants the predetermined capacitor charge is dissipated into the work at the same rate for each weld. Figure 6 shows oscillograms of repeated charging and discharging of the system.

Figure 7 is the schematic diagram of the "Hi-Wave" welding machine. The capacitor bank is charged by the closure of the line switch. When the voltage through the rectifier transformer on the capacitor has reached a predetermined value the switch is opened automatically. To make the weld the output switch is closed, thereby discharging the capacitor through the primary of the welding transformer which in turn causes the high welding current to flow in its secondary through the work.

The capacitor bank, charging and discharging circuits, voltage controls and transformer tap switch are contained in the control unit, Fig. 8. The control unit also houses the sequencing relays for the operation of the welding head.

On the panel of the control unit are the welding pressure regulator and gage; capacitor voltmeter, line current meter; capacitor charge controls, power switches, capacitor and turns ratio switches. A discharge button is provided for use in making initial voltage adjustments. At the extreme bottom of the panel are two jacks for convenient insertion of an oscilloscope in the discharge circuit for the observation of welding current wave shape.

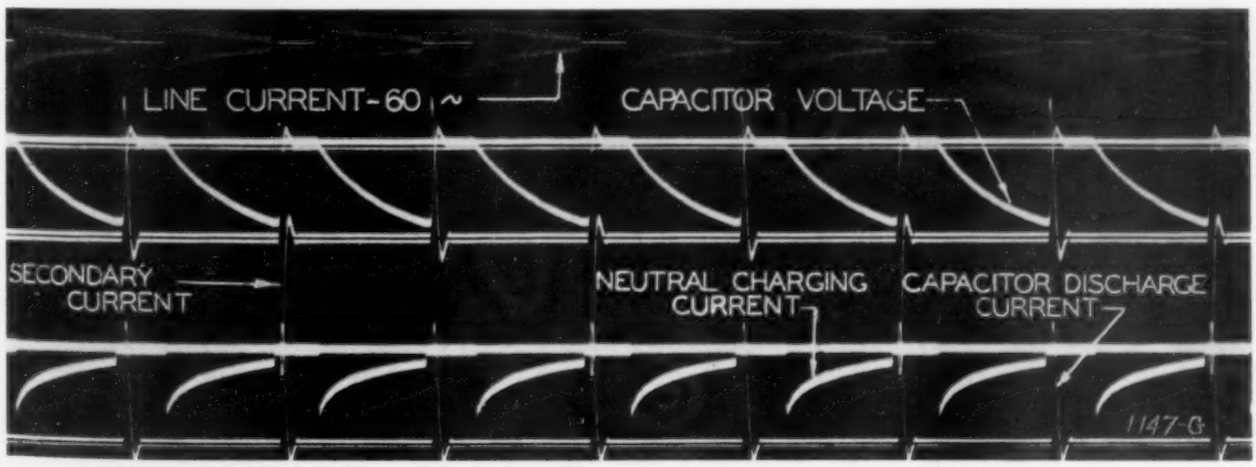

Fig. 6—Oscillograms of Repeated Charging and Discharging of Capacitive Stored Energy System

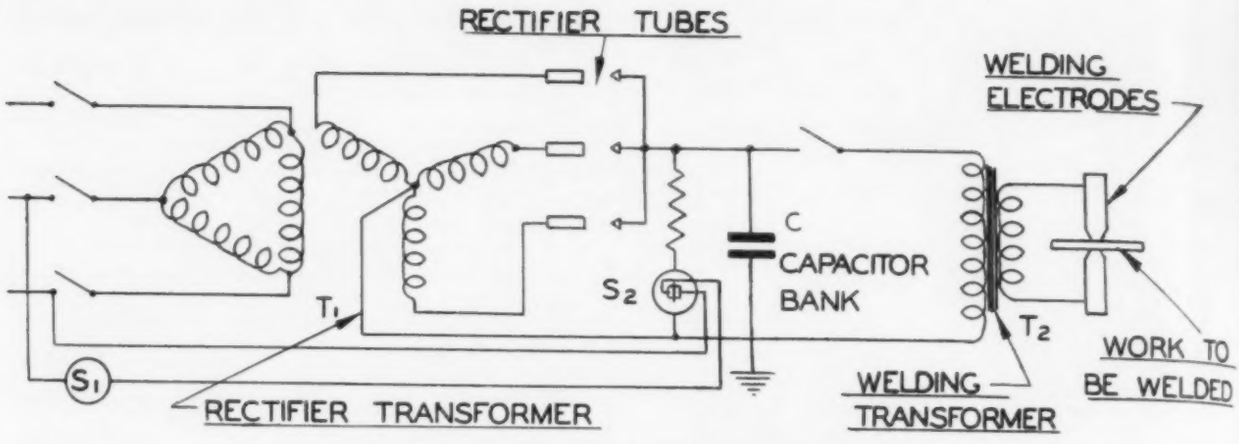

Fig. 7—Schematic Diagram of Capacitive Stored Energy System

In order that proper solidification of the weld takes place it is necessary that the machine be capable of exerting pressure on the work considerably in excess of that used on the conventional alternating current machine.

However, increased pressure alone would not insure the proper pressure at the time the weld is made. Since the weld metal contracts as it solidifies, the welding electrode must move following this contraction at the same rate that it occurs. If the welding electrode does not follow the contracting weld metal the pressure disappears and solidification takes place under inadequate pressure.

The movable system of either the rocker arm or press type of standard welding machine has high inertia and high static friction. When these heavy moving parts are at rest, as they are when the weld is being made, more force than is available is required to overcome the static friction to start motion, and overcome inertia to provide the necessary acceleration to maintain pressure on the rapidly contracting weld metals. It is practically impossible to produce clean non-porous welds on a standard machine which has not been especially designed to overcome static friction and high inertia.

The welder proper was designed to insure the required follow-up and pressure maintenance by using a very light head of aluminum alloy to minimize inertia, and an air lock to completely eliminate static friction (Fig. 9). The operating head consists of the head support proper, through the bearing of which operates the outer quill. This is a Meehanite casting and is ground to a very close fit in the head support. The upper portion of this quill is attached to the air cylinder piston rod. The lower portion of this outer quill acts as an air cylinder and in such use becomes an airlock. In this outer quill assembly is the inner quill assembly. The inner quill is provided with a cup leather which becomes the piston of the airlock.

In operation the cylinder head is moved into position on the work by means of the air cylinder and when the welding point contacts the work, the motion of the inner quill ceases. However, the actual total pressure exerted by the air cylinder exceeds the total pressure for which the airlock is set. Consequently when the inner quill is stopped in its downward motion, the outer quill continues to move, thus collapsing the airlock. The rate of speed of motion through the airlock due to the low

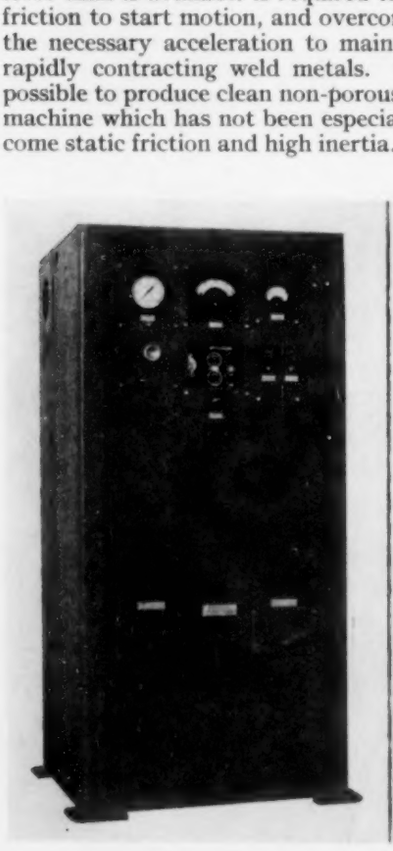

Fig. 8—Control Unit

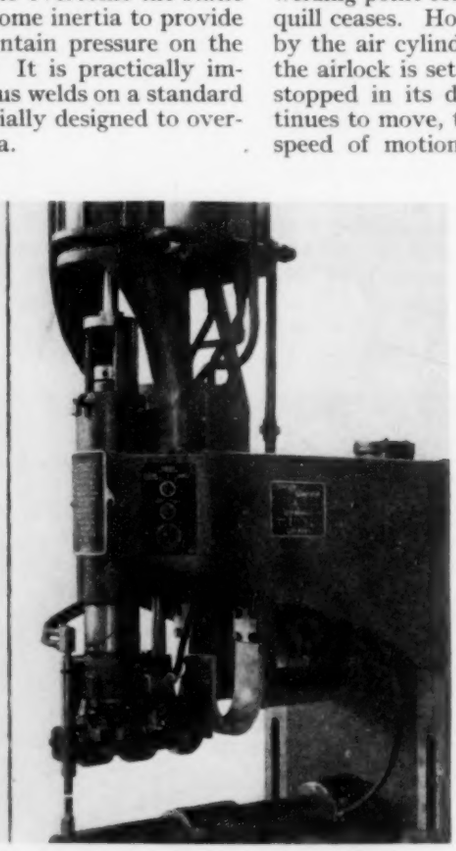

Fig. 9—Micro-Firing Switch

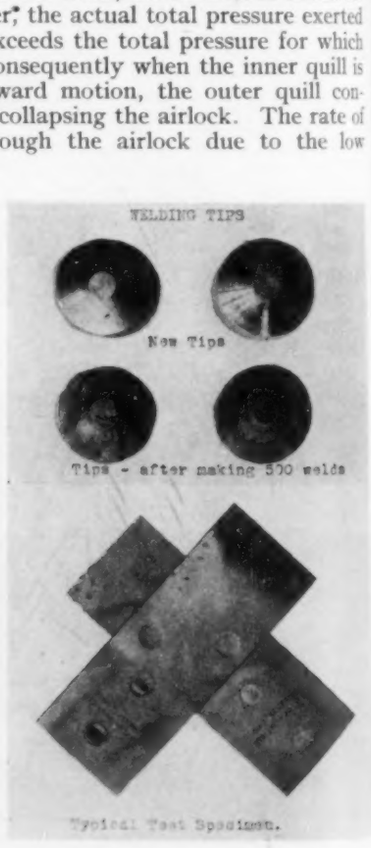

Fig. 10—Appearance of Tips

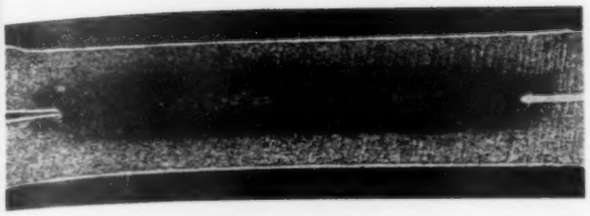

Fig. 11—Photomacro of Hi-Wave Weld in 0.020 Inch 24 St Alclad. Magnification—20 X

differential pressure between the airlock and the operating cylinder is very much slower than the original downward motion imparted by the air cylinder.

Figure 9 also shows the micro firing switch mounted on the outside of the airlock. The switch and switch bracket are mounted on the outer quill, while the trigger cam is mounted on the inner quill. Just as the airlock begins to collapse, the trigger sliding over the cam surface trips this switch, firing the weld. This is a very sensitive mechanism and the weld is actually fired as the airlock moves approximately $^1/_{32}$ inch. Since this is independent of all adjustments on the machine the weld will be fired at exactly the same relative point each time the weld is made.

While the weld is being made, the outer quill continues to move over the inner quill, thus completely eliminating all static friction.

It is desirable whenever possible to work with a very short operating stroke, yet it must also be possible to open the electrodes a sufficient distance to admit large sections into the throat of the machine. For this reason the machine is equipped with an air-operated adjustable retractable stroke mechanism. The adjustment for this feature is at the top of the main air cylinder and retraction is controlled by means of a foot switch.

When energy is applied at the high uniform rate that is possible using this method of welding the weld takes place at the interface of the two sheets of aluminum with insufficient time for any considerable conduction to the electrode face. Also the use of high-operating pressure decreases the generation of heat because of lowered contact resistance between the electrodes and the work. Two very important advantages are gained by so confining the heat to the weld zone. First, because the surface is relatively cool, there is less indentation. Second, for the same reason, electrode "pick-up" is greatly reduced. Welding point life is therefore increased to as much as 25 to 50 times that obtained with conventional alternating current welding. The appearance of new and used welding tips is shown in Fig. 10.

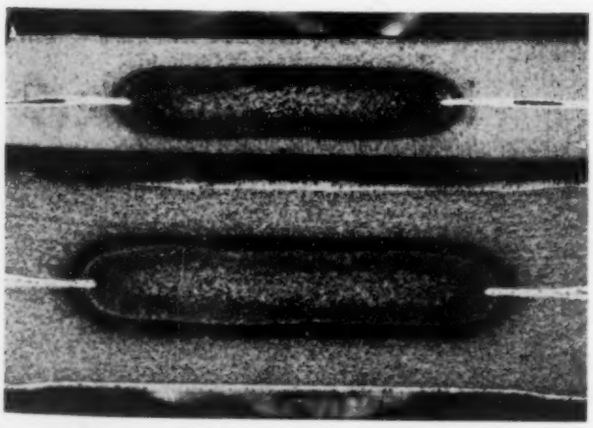

Fig. 12—Photomacro of Hi-Wave Weld in 0.038 Inch 24 St Alclad. Magnification—10 X

Fig. 13—Photomacro of Hi-Wave Weld in 0.064 Inch 24 St Alclad. Magnification—10 X

Figures 11, 12 and 13 are photomacrographs of welds in 0.020, 0.038 and 0.064 24 ST Alclad sheets showing the weld, extent of heat effect and surface indentation. Figures 14, 15 and 16 are dispersion charts showing the extremely uniform results obtained in consecutive welds on the above stock.

From the production standpoint the system of spot welding herein described has five outstanding advantages:

1. Uniform welds in strength and appearance.
2. Long point life.
3. High production.
4. Freedom from maintenance problems.
5. Simple inexpensive power requirements.

In addition to uniformity and long point life the system provides a high-production rate. Since the charging of the capacitors can be accomplished while the electrodes are separated, consequently while the work is being moved from one spot to another it is possible to attain almost any desired rate of speed. Speeds of 80 to 100 spots per minute can be obtained on the lighter gages, and speeds up to 60 spots per minute on heavier thicknesses. It is entirely possible to provide for a higher rate of operation but it is generally recognized that a pedestal type welder is inherently limited in its speed of operation by the fact that the work must be moved through its arms and this can seldom be done faster than indicated by the above figures, even though elaborate fixtures for handling material may be provided.

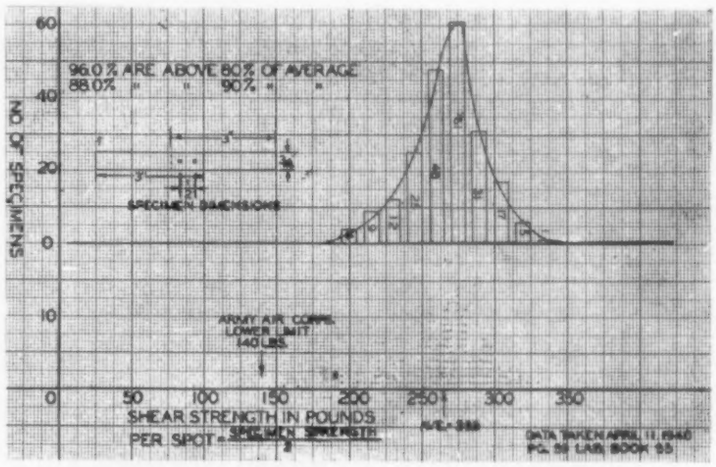
96.0 % ARE ABOVE 80% OF AVERAGE
88.0% " " 90% " "
NO. OF SPECIMENS
SPECIMEN DIMENSIONS
ARMY AIR CORPS LOWER LIMIT 140 LBS.
SHEAR STRENGTH IN POUNDS PER SPOT = SPECIMEN SHEAR STRENGTH / 2
AVE. 288
DATA TAKEN APRIL 11, 1940 PG. 58 LAB. BOOK 95

Fig. 14—Dispersion Chart on Shear Tests of 214 Specimens of 0.020 to 0.020-Inch 24 St Alclad

Maintenance has been minimized by eliminating the necessity of interrupting high currents. Standard parts including relays and rectifier tubes are used throughout to facilitate their replacement in the field if necessary.

Since the principle of this welder is fundamentally that of energy storage, comparatively low power demand is required, the charging of the capacitor being accomplished by means of a rectifier utilizing poly-phase power supply. All difficulties due to very high kva. input demands present in standard 60 cycle A.C. welding of aluminum are completely eliminated. The equipment also draws power from all three phases of the line thus eliminating unbalance of the system which occurs on single phase welders.

Tables 1 and 2 show the line demand on a standard alternating current aluminum welder as compared to that of a "Hi-Wave" welder.

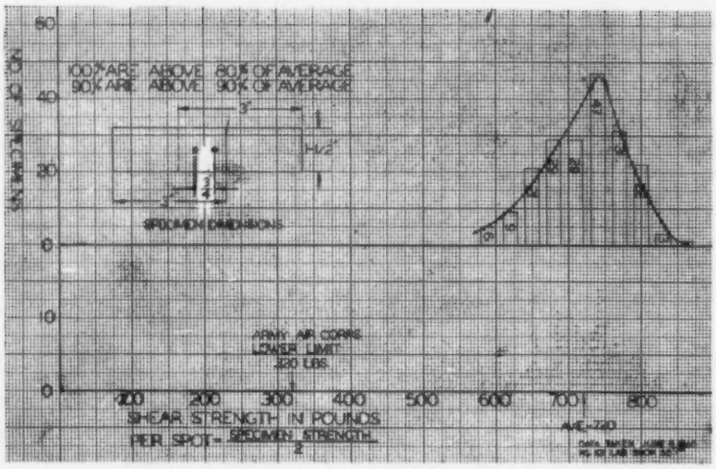
100% ARE ABOVE 80% OF AVERAGE
90% ARE ABOVE 90% OF AVERAGE
SPECIMEN DIMENSIONS
ARMY AIR CORPS
LOWER LIMIT
220 LBS.
SHEAR STRENGTH IN POUNDS
PER SPOT = SPECIMEN STRENGTH / 2

Fig. 15—Dispersion Chart on Shear Tests of 198 Specimens of 0.038 to 0.038 24 St Alclad

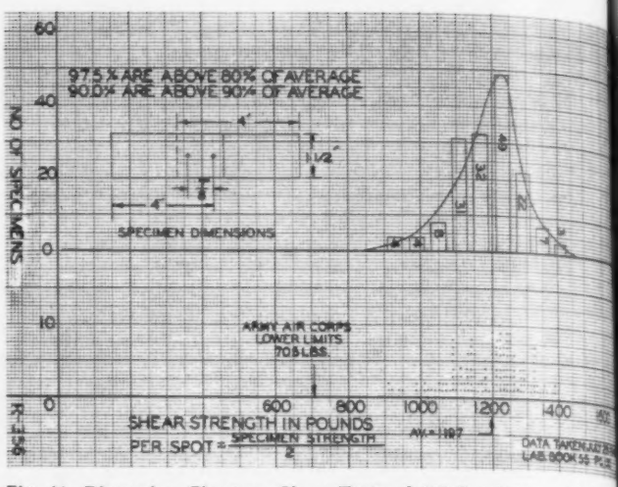
97.5% ARE ABOVE 80% OF AVERAGE
90.0% ARE ABOVE 90% OF AVERAGE
SPECIMEN DIMENSIONS
ARMY AIR CORPS
LOWER LIMITS
705 LBS.
SHEAR STRENGTH IN POUNDS
PER SPOT = SPECIMEN STRENGTH / 2

Fig. 16—Dispersion Chart on Shear Tests of 160 Specimens of 0.064 to 0.064 24 St Alclad

Table 1—Typical Kva. Demand on 60-Cycle Single Phase A.C. Aluminum Welded Machines

Ga. Aluminum	12 In.	18 In.	24 In.	30 In.	36 In.
0.020	50	60	70	80	90
0.040	75	80	95	110	130
0.060	100	125	140	150	190
0.080	150	160	190	210	250
0.125	200	250	300	330	400

Table 2— Kva., Demand of Hi-Wave Aluminum Welding Machines

Machine Size	Stock Thickness In.	Operating Speed S. P. M.	Kva. Demand
1	0.020	110	40
	0.035	90	40
3	0.060	70	50
	0.080	50	50
5	0.125	20	70

The success of this type of equipment is based entirely on the proper harmonizing of the design of the welding transformer and the design and construction of the mechanical features of the welding machine with the design of the control panel itself. These various units cannot be considered as separate items which can be supplied independently, but all must be properly engineered into a single complete functioning mechanism.

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(*Continued on page 124*)

Completion of Overpass for Cleveland's New Main Avenue Bridge

By J. R. Morrill*

COMPLETION of the East 9th Street overpass was the final step resulting in the opening of the new Main Avenue bridge project at Cleveland, Ohio. This structure, erected to relieve traffic in and out of the city via the lake front, was opened to the public December 12th. The structure has been in process for approximately 2 years.

The East 9th Street structure represents an additional use of welding to that employed in the main structure of the bridge in which there are over 70 miles of arc welded seams, including both shop fabrication and field connections of steel work. Included in the welded structure of the main bridge are two 120-foot spans which connect the north and south ramps to the westerly approach. These spans themselves contain approximately 40 miles of arc-welded seams. Other welded work in the bridge proper includes $14^1/_2$ miles of seams in the floors, 10 miles in the railings, $4^1/_2$ miles in the steel curbing and 1 mile in the lighting standards.

Figure 1 is a general view of the structure.

Figure 2 shows welding of end plating to the main structure.

A view on the opposite side to that shown in Fig. 2 is provided in Fig. 3. Pressed steel, formed into streamlined designs, is used to improve the appearance of the span. In the picture, the welder is applying plating.

A channel and angle section welded on top of one of the riveted girders to provide one of the curbs and supports for the walkway at the side of the bridge can be seen in Fig. 4. The channel is welded by intermittent beads to the top flange of the girder while the angle is welded to the top flange of a channel. The floor grading fits into this angle extending over the main girder on the right of Fig. 4.

As shown in Fig. 5, the pressed steel shapes, comprising

* The Lincoln Electric Company, Cleveland, Ohio.

Fig. 1—View of East 9th Street Overpass, Final Connecting Link of the New Main Avenue Bridge Project at Cleveland

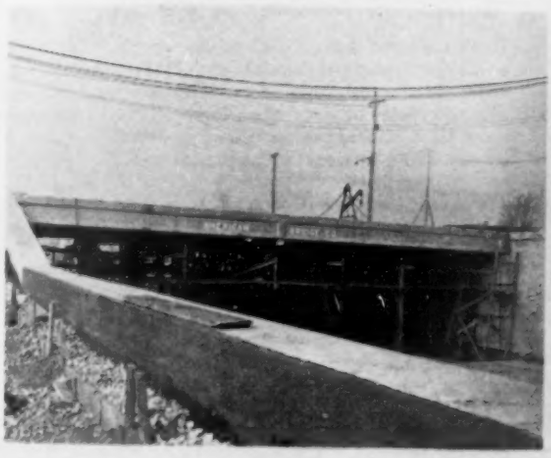

Fig. 2—Arc Welding End Plating to Main Structure of East 9th Street Overpass at Cleveland

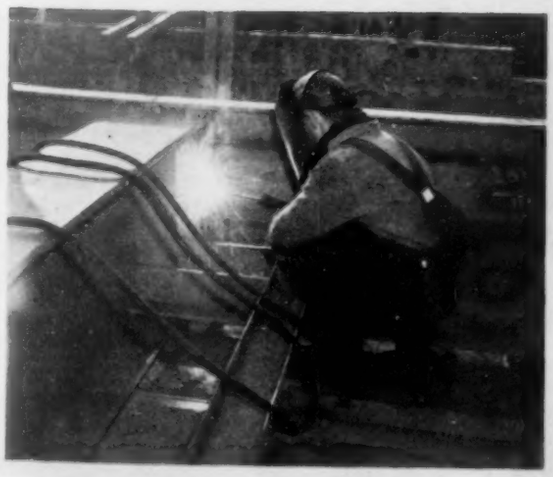

Fig. 3—Arc-Welded Pressed Steel, Formed Into Streamlined Designs, Enhances Appearance

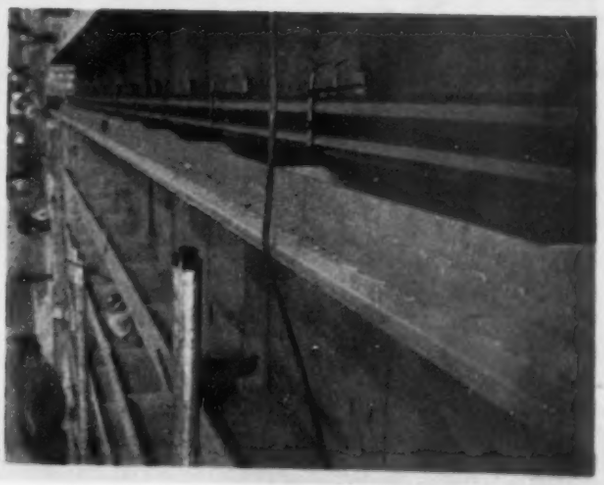

Fig. 4—Channel and Angle Section Arc Welded to Girder Serve as Curb and Support for Walkway

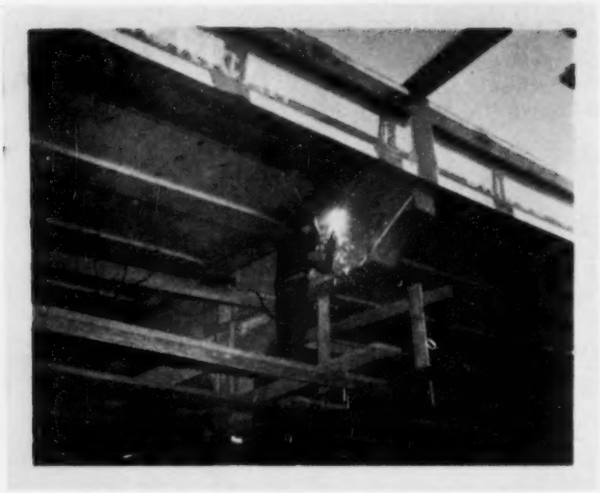

Fig. 5—Pressed Steel Shapes Arc Welded to the Main Girders of the East 9th Street Overpass

Fig. 6—Another View Showing the Pleasing Appearance Obtained with Welded Pressed Steel Shapes

the roof for the overpass, are welded to the main girders intermittently. The spacing of the welds is shown by the dark marks visible in the photo. The steel sheets are joined, one to the other, by continuous butt welds made in the overhead position. These welds are chipped with a pneumatic hammer to remove slag and eliminate grinding.

A general view showing the pleasing appearance obtained with welded pressed steel shapes is evident in Fig. 6.

Current Welding Literature

(*Continued from page 122*)

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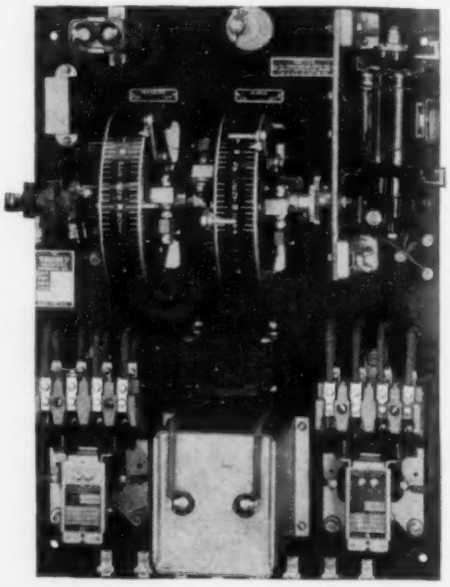
Custom Built



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ACTIVITIES Related Events

PRESIDENT'S MESSAGE

During times like the present when the problem of National Defense is paramount, the question may be raised as to the value of participation in the activities of our technical societies. The demand is for production and more production. There is not time to extend knowledge. We must rather apply available knowledge to the solution of this one problem, neglecting other things that may be desirable. Thus, our technical societies cannot expect our support as National Defense demands all our efforts.

A deeper analysis of current activities, however, discloses phases of the problem that furnish opportunities of service that the technical societies are peculiarly well adapted to exercise. Only one of those phases will be discussed here, although there are many others.

When a single industry grows to mammoth proportions overnight there are tremendous problems both as to facilities and as to personnel. Existing plants must be revamped to produce new articles and new plants must be erected. The previous balance as to the relative use of the methods of processing is disturbed. Some processes become of less importance but many become of greatly increased importance. The welding process is one of those of increasing importance in the National Defense industry. In some communities a new welding industry is being developed, in others welding fabrication plants are being greatly expanded.

The welding industry is concerned with training of new operators and engineers. It is also concerned with the development of its existing personnel. In many respects, this is the more important problem.

The development of the art and science of welding has been so rapid in recent years that the literature does not contain current practice. Text-books are incomplete and existing practice has not been incorporated into Standards and recommended practices. Design practice is still in a state of flux.

Under these conditions it is necessary to maintain personal contact with developments. It is impracticable for any one individual or any one organization acting independently to reach the same level of development as the industry. Few single individuals or organizations command access to these developments. A large group of interested engineers do have that privilege. In other words, the local sections of our technical societies have the power to secure lectures by the most progressive engineers of industry. Some sections of the AMERICAN WELDING SOCIETY are carrying on activities of that type and securing attendance at meetings in excess of their total membership.

There are few communities in which there are not some engineers willing to devote some time and energy to the organization of such educational work. Were there a full realization of the importance of such efforts to National Defense, there would be a larger number willing to give their services. The WELDING SOCIETY offers facilities and assistance in organizing such activities. It has a liberal policy in assisting local Sections.

The SOCIETY is interested in hearing from engineers willing to organize such activities especially in communities where a local Section is inactive or where no local Section exists. It offers an opportunity for a real contribution to National Defense.

NOMINATING COMMITTEE

With the approval of the Executive Committee the President has appointed the following members to constitute the 1940–1941 Nominating Committee:

Mr. H. C. Boardman, Chairman, Chicago Bridge and Iron Co., 1305 W. 105th St., Chicago.

Mr. J. J. Crowe, Air Reduction Sales Co., 60 East 42nd St., New York.

Mr. C. H. Jennings, Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.

Mr. J. F. Lincoln, Lincoln Electric Company, Cleveland, Ohio.

Mr. P. D. McElfish, Standard Oil Co. of Calif., Box 2437, Los Angeles, Calif.

Mr. Gwynne Raymond, Black, Sivalls & Bryson, Inc., Oklahoma City, Okla.

Mr. J. D. Tebben, P. R. Mallory & Co., Indianapolis, Ind.

The By-laws require that these names be published in the JOURNAL on or before March 1st. The Committee is required to deliver to the Secretary in writing on or before the last Tuesday in May, the names of its nominees for the various elected officers next falling vacant, together with the written acceptance of each nominee.

The purpose of publishing the names of the Nominating Committee in the JOURNAL is to provide every member with an opportunity to make suggestions to the Nominating Committee. To be effective, it is essential that these suggestions be sent in at once as, naturally, the Nominating Committee will be required to hold early meetings in order to fulfill its duties as required by the By-laws.

The offices to be filled are:

President, First Vice-President, Second Vice-President, Treasurer, 4 Directors.

All of the present incumbents are eligible for reelection (their names are given in the Year Book).

The Directors-at-Large are selected by the Nominating Committee, with due consideration to geographic distribution.

WESTERN METAL CONGRESS AND EXPOSITION

The fourth Western Metal Congress and Exposition will be held in Los Angeles, May 19th to 23rd inclusive. The AMERICAN WELDING SOCIETY is cooperating with the American Society for Metals in arranging for this conference. It will follow the pattern of the very successful Congress held in 1938.

It is anticipated that the attendance will be around 60,000 which is approximately 50% more than the attendance in 1938. This larger attendance will be made possible by the considerable increase in industry in this section of the country, the aircraft and the shipbuilding industry, in particular.

A number of the principal manufacturing companies, including, General Electric, Victor Equipment, Air Reduction Sales, Lincoln Electric and The Linde Air Products, have arranged for space.

The AMERICAN WELDING SOCIETY has already arranged for several Eastern speakers and are concentrating their efforts on keymen in the industries throughout the United States, and when the program is finally drawn up will represent a cross section of welding activities throughout the United States.

Mr. J. Gowing is Chairman of the Program Committee. Mr. L. W. Delhi, recent vice-president, will head the list in the activities of the A.W.S. in cooperation with the American Society for Metals, E. O. Williams, publicity chairman, J. C. Blake, entertainment chairman, and a well-known industrialist will be announced shortly as honorary chairman.

TENTATIVE SPECIFICATIONS FOR FACTORY-MADE WROUGHT CARBON-STEEL AND CARBON-MOLYBDENUM-STEEL WELDING FITTINGS

A. S. T. M. Designation: A 234 – 40 T, issued, 1940. This Tentative Standard of the American Society for Testing Materials is, under its Regulations, subject to annual revision. Suggestions for revision should be addressed to the Society, 260 S. Broad St., Philadelphia, Pa. Copies for this purpose may be obtained by writing direct to the A. S. T. M.

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MEMORIAL RESOLUTION CHARLES A. McCUNE

A Committee appointed by the AMERICAN WELDING SOCIETY has drawn up the following resolution:

WHEREAS, in the death of its Treasurer and Past President, Charles A. McCune, the AMERICAN WELDING SOCIETY has suffered an irrevocable loss; therefore be it

RESOLVED, That we, the Board of Directors, assembled in Cleveland on October 25, 1940, transmit to Mrs. McCune and to the other members of his family, not only our deepest sympathy, but also our conviction and faith that his spirit is still carrying on in each of our hearts as well as in those of hosts of other friends, and that his integrity, wisdom, loyalty and affection have left a mark which will endure as long as time lasts.

A suitable engrossed certificate was sent to Mrs. McCune.

INSTITUTE OF STEEL CONSTRUCTION PROMOTIONS

The American Institute of Steel Construction, Inc., 101 Park Avenue, New York, N. Y., has announced that effective January 1, 1941, Mr. F. H. Frankland, Chief Engineer and Technical Director of the Institute, became its Director of Engineering and will devote his entire time to technical research related to the use of structural steel and to other engineering matters with which the institute is concerned.

Mr. T. R. Higgins, who has been in charge of the institute's New York metropolitan office for the past year, became Chief Engineer and will hereafter supervise and manage the operations of the institute's district offices throughout the country.

It is expected that this arrangement will enable the institute to materially improve its engineering service and to personally contact its members in each district more frequently.

FEDERAL GOVERNMENT NEEDS ENGINEERING DRAFTSMEN

Engineering draftsmen in various optional fields are urgently needed by the United States Government. A civil service examination held last fall failed to produce enough eligibles to meet the demand of the national defense program. The United States Civil Service Commission has, therefore, reannounced the examination and will accept applications until December 31, 1941. The salaries of the positions range from $1,620 to $2,600 a year, less a 3½ per cent retirement deduction.

Optional branches in which applicants may qualify are: Architectural, civil, electrical, heating and ventilating, lithographic, mechanical, plumbing, radio, structural, topographic and general—which includes any other branch except aeronautical, ordnance or ship.

Competitors will not be required to take a written test, but will be rated on their education and experience as shown in their applications, and on corroborative evidence.

Further information and application forms may be obtained from the Secretary of the Board of U. S. Civil Service Examiners at any first- or second-class post office, or from the U. S. Civil Service Commission, Washington, D. C.

METALLURGISTS AND METALLURGICAL ENGINEERS NEEDED FOR NATIONAL DEFENSE WORK

The United States Civil Service Commission has announced that it will again receive applications for positions of metallurgist and metallurgical engineers, various grades, with salaries ranging from $5600 to $3200 a year. An insufficient number of eligibles for filling these positions resulted from the examination which closed in September 1940. Difficulty is being encountered in filling positions in the Bureau of Mines in connection with the National Defense Program for the development of strategic metals. Qualified persons are urged to send their applications to the Commission's Washington office at once where they will be rated as received until December 31, 1941.

Applicants will not be given a written test. They will be rated on their educational training and experience. A 4-year

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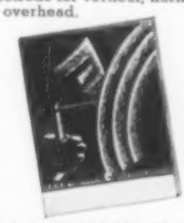

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college course with major study in chemistry, geology, mining, physics, engineering or metallurgy is required plus responsible experience in metallurgy or metallurgical engineering. For the associate grade, appropriate graduate study may be substituted for the entire experience requirement; for the other grades, a partial substitution may be made. In each case, the graduate study must have specific value in the branch of metallurgy or metallurgical engineering in which the applicant wishes to be rated.

Applicants must not have passed their sixtieth birthday on the date of receipt of application. The salaries for all grades are subject to a $3\frac{1}{2}$ per cent deduction toward a retirement annuity.

Further information regarding the examination and the proper application forms may be obtained from the Secretary of the Board of U. S. Civil Service Examiners at any first- or second-class post office, or from the United States Civil Service Commission, Washington, D. C.

OBITUARIES

H. Goldmark

Henry Goldmark, retired civil engineer, an associate of the late General G. W. Goethals in the construction of the Panama Canal, died January 15th in Nyack Hospital of injuries received, when he was struck by an automobile on Broadway, Nyack. His age was 83.

Young Goldmark studied at the Collegiate and Polytechnic Institute in Brooklyn, and was graduated from Harvard University in 1878. He took post-graduate courses at the Royal Polytechnic School in Hanover, Germany, and in 1880 joined the Erie Railroad as a bridge builder.

He was one of the first to use steel in bridge construction. Mr. Goldmark designed and built bridges for the Kansas City, Memphis & Gulf Railroad, went to Texas with the locating party for what is now the Cotton Belt Route, spent four years in inspecting metallurgical and structural plants throughout the country, and was hired to report on the safety of bridges by several other railroads, including the Santa Fe, the Boston & Maine and the Chesapeake & Ohio.

From 1891 to 1896 he worked on the design of buildings for the Chicago World's Fair, and later took charge of the hydroelectric plant of the Pioneer Electric Power Company at Ogden, Utah, one of the largest in the country. Next, Mr. Goldmark became associated with George S. Morrison in planning the viaduct on Connecticut Avenue, Washington, D. C., where it crosses Rock Creek, and then joined the United States Board of Engineers on Deep Waterways.

In 1906 Mr. Goldmark went to Washington to design the lock gates for the Panama Canal, directed their construction at Pittsburgh and went to the Canal Zone to supervise installation, the work covered the period 1906–14.

Since then he had been a member of the Board of Consulting Engineers of the New York Barge Canal and a consulting engineer to New York City. Mr. Goldmark supervised many important projects throughout the world. These included designing the harbor equipment for the Japanese Government at Chemulpo, Korea; the locks for the Inner Navigation Canal at New Orleans, chairmanship of the board to pass on the design of the Navy airship Shehandoah and the Navy Airship RS 1 (1924), work on the Passamaquoddy Bay hydroelectric plant and work on a proposed giant radio station near Shanghai, China. He had not been active since 1925.

Mr. Goldmark was a member of the American Society of Civil Engineers, the Institute of Civil Engineers of Great Britain, the Engineering Institute of Canada, the Western Society of Engineers and of the Engineers' and Harvard Clubs.

Mr. Goldmark has prepared several papers for the AMERICAN WELDING SOCIETY, of which he was a member until his retirement.

FRED R. DAVIS, G-E ADVERTISING MAN, DIES AT 64

Fred R. Davis, a founder of the Audit Bureau of Circulations and advertising space buyer for the General Electric Company at Schenectady for 35 years, died December 26th at this home in Schenectady after an illness of two years. He was 64 years old. For many years he

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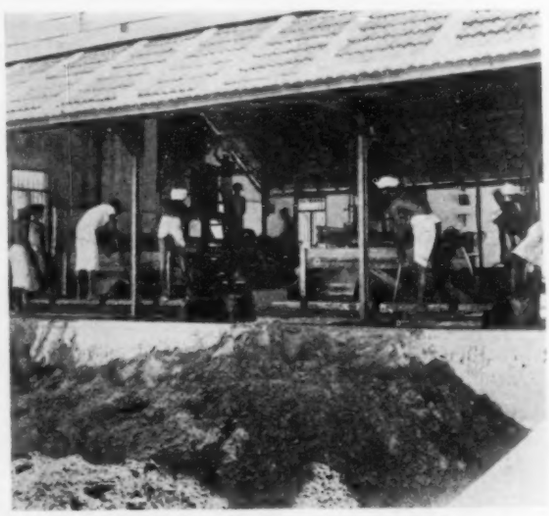

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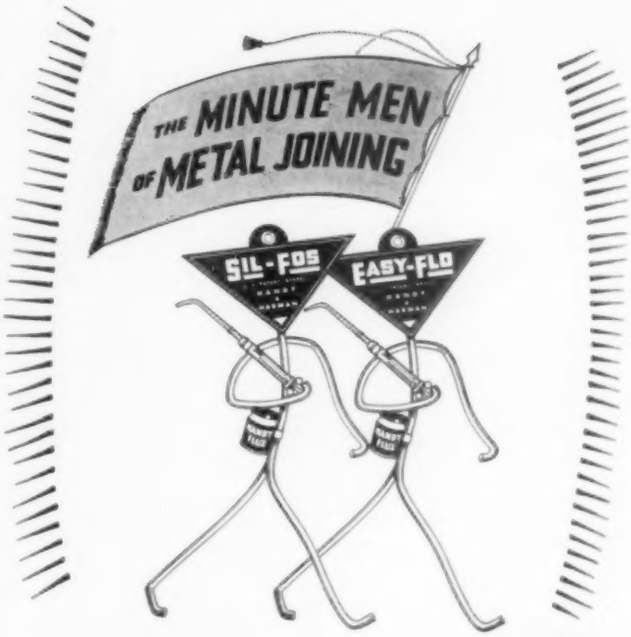

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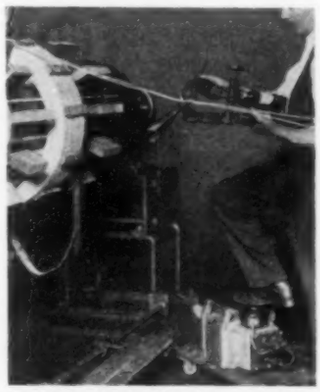

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A man of scientific training himself, Mr. Davis was a pioneer advocate of accurate measurement in advertising and helped found the Audit Bureau of Circulations in 1914. He served as a director from that date until his death and since 1927 had also been first Vice-President of the organization.

Mr. Davis was born in Adams, Mass., attended Union College in Schenectady, and was graduated from Worcester Polytechnic Institute in 1900 with the degrees of B.S. and M.S. in engineering. In 1901, he entered the G-E organization as a test student and in 1902 went to Fort Wayne, Ind., as publicity manager of the Fort Wayne Electric Company. In 1905 he joined the G-E advertising department in Schenectady.

He was an elder of the First Presbyterian Church of Schenectady, a member of the Technical Publicity Association and a member of the Phi Gamma Delta fraternity.

ARC WELDED DUCT

The accompanying picture shows a welded cinder duct built by Mack Bros. Boiler & Sheet Iron Works of Syracuse, N. Y., for the Bell Co., Worcester, Mass.

Fabrication of this duct was a rush job and the welding foreman in charge reports that only the high speed welding made possible by heavy coated welding electrodes enabled him to complete the duct within the time limits of the contract.

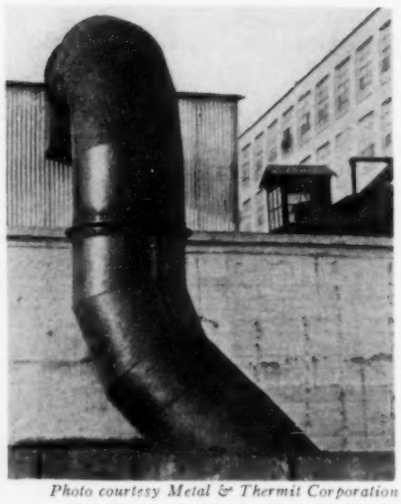


Photo courtesy Metal & Thermit Corporation

MEETING EXECUTIVE COMMITTEE AMERICAN WELDING SOCIETY

A meeting of the Executive Committee of the AMERICAN WELDING SOCIETY was held on December 12th in the Engineering Societies Building. The following were present: President G. F. Jenks, presiding; C. A. Adams, David Arnott, A. G. Bissell, H. C. Boardman, R. W. Clark, E. V. David, J. H. Deppeler, C. L. Eksergian, E. R. Fish, O. B. J. Fraser, J. D. Gordon, K. L. Hansen, H. O. Hill, D. S. Jacobus, Albert S. Low, L. S. Moisseiff, H. S. Smith, A. C. Weigel, W. Spraragen, M. M. Kelly.

Budget for Fiscal Year Commencing October 1, 1940

The Treasurer in presenting the budget called attention to the need for exercising caution because of cash stringency resulting from a change-over to a single expiration date for membership dues. The budget was adopted and represents a slight increase of expenditures over that of last year.

Replacement of Directors

The Executive Committee voted to refer the following candidates to the Board for election by letter ballot to fill vacancies: E. R. Fish, Hartford Steam Boiler, Insp. and Ins. Co., Hartford, Conn., for term ending October 1941; A. C. Weigel, Combustion Engineering Co., New York, N. Y., for term ending October 1942.

Code for Minimum Requirements for Training of Welding Operators

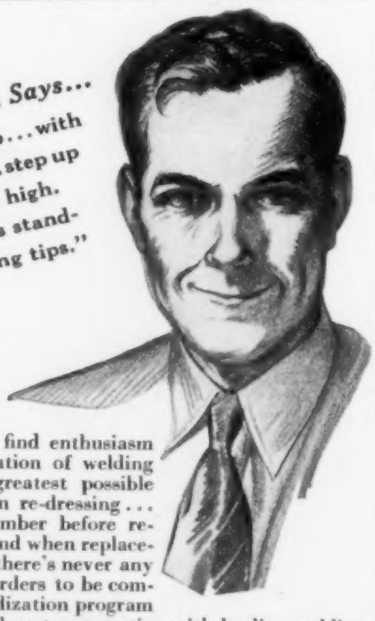
It is expected that the first draft of this report will be available very shortly.

Industrial Training of Welding Operators

The Editor was encouraged to solicit papers from various industrial companies on the training of welding operators as practiced successfully by those companies. All members of the SOCIETY having pertinent information on this subject are requested to communicate with the Editor.

The Shop Foreman Says...

"I've watched our shop...with the same operators...step up to a new production high. Thanks to Mallory's standardization of welding tips."



All along the line you'll find enthusiasm for Mallory's standardization of welding tips. They insure the greatest possible number of welds between re-dressing... the greatest possible number before replacement is necessary. And when replacement must be made . . . there's never any need to wait for special orders to be completed. Mallory's standardization program has covered years of the closest cooperation with leading welding machine manufacturers. You can be sure of the exact tip you need for your purpose and machine. Why not cash in on the investment Mallory has made to insure better, cheaper welds?

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● Headlines in the news! The story of American industry's gigantic effort to add speed ... efficiency ... and more speed to the production of vital war and defense products. A story that goes back through recent years of development in industrial methods in order to explain how such vast improvements are available for immediate application today. A major factor in the accomplishment of this program is Resistance Welding. For the past fifteen years, Resistance Welding has worked closely with peace-time industry in developing advanced welding machines for faster, improved metal fabrication. Applied to present-day emergency needs, its contribution is at peak importance.

Consult any of the member companies listed here. They have experienced engineers available who can show you what results Resistance Welding can accomplish in your plant.

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MEMBER COMPANIES

Progressive Welder Company, Detroit, Mich.
Swift Electric Welder Company, Detroit, Mich.
Taylor-Hall Welding Corporation, Worcester, Mass.
Taylor-Winfield Corporation, Warren, Ohio
Thomson-Gibb Electric Welding Co., Lynn, Mass.
Welding Machines Mfg. Co., Detroit, Mich.
Acme Electric Welder Company, Huntington Park, Calif.
Eisler Engineering Company, Newark, N. J.
Expert Welding Machine Co., Detroit, Mich.
Federal Machine and Welder Company, Warren, Ohio
Multi-Hydromatic Welding and Manufacturing Co., Detroit, Mich.
National Electric Welding Machines Co., Bay City, Mich.

ASSOCIATE MEMBER COMPANIES

Welding Sales and Engineering Co., Detroit, Mich.
P. R. Mallory and Co., Indianapolis, Ind.
S-M-S Corporation, Detroit, Mich.
Electroloy, Inc., New York City

1941 National Metals Exposition and Congress

The Executive Committee voted to accept the invitation of the American Society for Metals to participate in the 1941 National Metals Exposition and Congress, and to authorize the holding of the 1941 Annual Meeting of the Society in Philadelphia at the time of the Metals Congress and Exposition. The Bellevue Stratford Hotel was selected as the headquarters of the SOCIETY.

Standing Committee Personnel

On recommendation of President Jenks, and with the approval of the Committees concerned, the following changes in committee personnel were approved:

Outline of Work Committee.—Additions: W. Spraragen, Secretary, and G. V. Slottman.

Meetings and Papers Committee.—Additions: H. L. Rogers, R. E. Powell, J. S. Sheffer, R. S. Donald, H. W. Lawson. Replacement: E. A. Doyle to replace J. S. Murphy. Deletions: S. L. Hoyt and Jonathan Jones.

Admission to Membership Committee.—Addition: E. A. Balsley. Deletion: P. W. Swain.

Manufacturers Committee.—Replacement: V. H. Van Diver to replace W. P. Burglund.

Technical Committee Appointments

On request of the Committee on Outline of Work the following appointments were approved:

Committee on Rules for Field Welding of Storage Tanks.—Addition: L. R. Howson, Alvord, Burdick & Howson, Chicago, Ill.; G. Raymond, Black, Sivalls & Bryson, Oklahoma City, Okla.; M. V. Reed, Wyatt Metal & Boiler Works, Houston, Texas.

Committee on Non-Destructive Tests for Welds.—Addition: Bureau of Ships, Navy Department, Washington, D. C.; Dr. H. H. Lester, Watertown Arsenal, Watertown, Mass.; W. D. Halsey, The Hartford Steam Boiler Ins. & Ins. Co., Hartford, Conn.

A. W. S. Representative on A. T. A. Way and Structures Committee No. 3—Welding.—J. B. Tinnon, Metal & Thermit Company, New York, to replace Mr. J. H. Deppeler.

Committee on Preparation of Recommended Practices for Inspection of Welding.—A. N. Kugler, Air Reduction Co., to replace Mr. LaMotte Grover of same Company, as the N. E. M. A. representative; representative from National Board of Boiler and Pressure Vessel Inspectors.

Committee on Standard Tests for Welds.—A. N. Kugler, Air Reduction Co., to replace Mr. LaMotte Grover of same Company.

Committee on Standard Qualification Procedure.—J. F. Randall, Combustion Engineering Co., New York, to replace Mr. E. C. Chapman of same Company.

Filler Metal Specifications Committee.—Ray Glenn, American Steel & Wire Co., to replace Mr. W. T. Cramer of same Company.

Resistance Welding Standards Committee

The following personnel were recommended for appointment on the above Committee subject to their acceptance:

John D. Gordon (*Chairman*), Taylor-Winfield Corp., Warren, Ohio.
G. S. Mikhalapov, Baldwin-Southwark Corp.
J. F. Randall, Combustion Engineering Corp.
Paul Merriman, Glenn L. Martin Company.
Mr. Merryman, Westinghouse Electric & Mfg. Co.
Mr. Newman, Ford Motor Company.
J. R. Stitt, Ohio State University.
Frank B. Bolte, Boeing Aircraft Corp.
M. F. Sayre, Union College, Schenectady, N. Y.
Mr. Hibert, Consolidated Aircraft.
Don Berlin, Curtiss-Wright Corp.
Mr. S. L. Rich, Bell Aircraft Corp.
David Cronin, National Cash Register Co.
Robt. Bowman, Wright Field.
Lee W. Clark, Detroit Edison Company.
J. D. Wright, General Electric Co., Schenectady, N. Y.
All members of R. W. M. A. Standards Committee.
R. T. Gillette, General Electric Co., Schenectady, N. Y.
C. F. Marchner, McDonnell Aircraft Corp., Robertson, Mo.
C. E. Heitman, A. O. Smith Corp., Milwaukee, Wisc.
F. H. Roby, Square D, Company, Milwaukee, Wisc.
E. H. Vedder, Westinghouse Electric & Mfg. Co., Pittsburgh, Pa.
O. Fredericks, General Electric Company, Philadelphia, Pa.
W. F. Hess, Rensselaer Polytechnic Institute, Troy, N. Y.
L. C. Bibber, Carnegie-Illinois Steel Co., Pittsburgh, Pa.
John Fetcher, E. G. Budd Mfg. Co., Philadelphia, Pa.
C. W. Dodge, Vought-Sikorsky, Stratford, Conn.
H. M. Steward, Westinghouse, E. Springfield, Mass.
Roy H. McCrory, Inland Div. General Motors, Dayton, Ohio.
G. S. Bernard, Aluminum Co. of America, New Kensington, Pa.
Mrs. Mabel Rockwell, Lockheed Aircraft, Los Angeles, Calif.
R. E. Kinkead, Consulting Engineer, 3441 Lee Road, Cleveland, Ohio.
W. L. Warner, Watertown Arsenal.
S. M. Spice, Buick Motor Car, Flint, Mich.
W. E. Geilselman, Great Lakes Steel.
A. W. Woodward, Goodyear Tire & Rubber, Akron, Ohio.
J. W. Sheffer, American Car & Foundry Company.
C. L. Pfeiffer, Western Electric, Chicago, Ill.
Joseph Lex, Fisher Body, Detroit, Mich.
I. T. Hook, American Brass Company.
Godfrey Burroughs, Chevrolet, Flint, Mich.
John Dykstra, Oldsmobile, Flint, Mich.
A. M. Unger, Pullman Standard Car Mfg. Company.
H. O. Klinke, Philadelphia Navy Yard, Bureau of Ships, Navy Dept., Washington, D. C.
R. A. Webster, Douglas Aircraft, Santa Monica, Calif.
A. House, R. C. A., Camden, N. J.
Ross Heilman, Wall Wire Products, Plymouth, Mich.
Lester Jones, Sperry Products, Hoboken, N. J.
C. M. Manzer, General Electric Company, West Lynn, Mass.
J. W. Dawson, Raytheon, Waltham, Mass.
Col. G. F. Jenks, Ordnance Dept., Washington, D. C.
E. C. Graves, International Harvester, Chicago, Ill.
C. L. Watson, Chevrolet Commercial Body, Indianapolis, Ind.
C. S. O'Neil, Hamilton Mfg. Co., Two Rivers, Wis.
E. R. Spittler, General Electric Company, Schenectady, N. Y.
R. S. Pelton, General Electric Company, Schenectady, N. Y.
J. B. Johnson, Army Air Corps, Wright Field, Dayton, Ohio.
O. B. J. Fraser, International Nickel Co., New York, N. Y.
M. B. Gathman, Fisher Body, Detroit, Mich.
F. R. Hensel, P. R. Mallory Company, Indianapolis, Ind.
H. B. Huester, Bureau of Aeronautics, Navy Dept., Washington, D. C.
Mr. Sefkenen, Vega Airplane Co., Burbank, Calif.
Charles Gallant, North American Aviation, El Segundo, Calif.
V. H. Pavlecka, Northrupt Aircraft, Hawthorn, Calif.
Mr. Weeks, Vultee Aircraft.

Reorganization of Committee on Rules for Field Welding of Storage Tanks

The Committee on Outline of Work recommends the approval of the revised organization of this Committee as shown below.

Personnel of Main Committee

H. O. Hill, *Chairman*	C. W. Obert, Sr.
L. M. Dalcher, *Secretary*	G. Raymond
H. C. Boardman	M. V. Reed
E. W. Fowler	Walter Samans
L. R. Howson	H. A. Sweet
J. O. Jackson	H. T. Welty
A. W. Johnson	

Personnel of Conference Committees

A. P. I.–A. W. S. Conference Committee on All-Welded Oil Storage Tanks

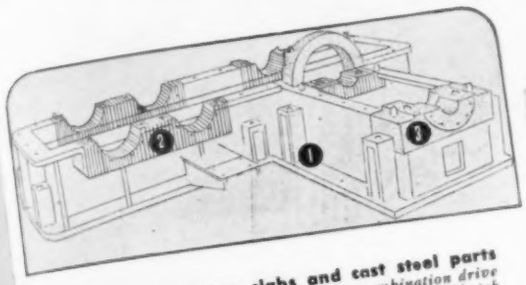
A. W. S. Members	*A. P. I. Members*
H. O. Hill, Chairman of Joint Committee	Walter Samans
H. C. Boardman	T. D. Tifft
C. W. Obert, Sr.	T. C. Smith
M. V. Reed	C. C. Ashley
G. Raymond	H. M. Stevenson

A. W. W. A.–A. W. S. Conference Committee on Elevated Steel Water Tanks, Standpipes and Reservoirs

A. W. S. Members	*A. W. W. A. Members*
H. C. Boardman	L. R. Howson, Chairman of Joint Committee
H. O. Hill	H. A. Sweet
J. O. Jackson	J. P. Schwada
C. W. Obert, Sr.	N. T. Veatch, Jr.

A. R. E. A.-A. W. S. Conference Committee on Welded Storage Tanks and Elevated Tanks for Railway Service

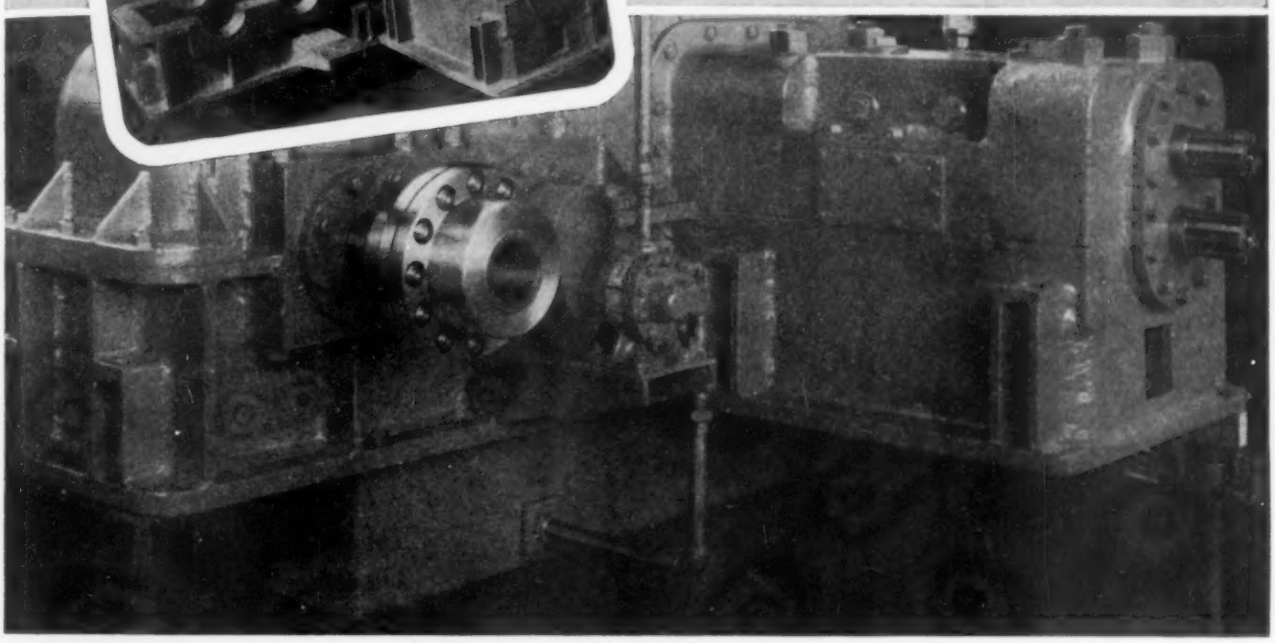
"Welding rolled steel
offers a lot more advantages than we thought"



Rolled steel plates, slabs and cast steel parts *are effectively combined in this heavy combination drive unit. Inset shows lower half of this assembly. Sketch shows in white (1), parts fabricated from plates; in hatched areas (2), parts flame-cut from slabs; in dotted areas (3), cast steel parts.*

For lighter, stronger, longer-wearing equipment fabricate it by welding with these better steels:

U·S·S Cor-Ten—to resist corrosion, to reduce weight or increase strength.
U·S·S Man-Ten — to increase strength without adding weight.
U·S·S Abrasion Resisting Steel— for use where abrasive conditions are exceptionally severe.
U·S·S Heat Resisting Steel—to combat high temperatures.
U·S·S Stainless Steel—to resist corrosion of all kinds.
U·S·S Carilloy Alloy Steels–to carry tremendous bearing pressures.



"OF course we have been using rolled steel right along in machine construction. It saves time and money. But the modern special steels now available, together with the improvements in welding and flame-cutting practices, have opened up possibilities we never thought of before.

"Now we can design equipment with its true functional requirements in mind—every part can be made to perform at fullest efficiency. And our machines not only function better, but are better looking and generally cost less to fabricate."

Designers and fabricators everywhere are saying just that. They are realizing that welded, rolled steel construction permits them to use the entire range of metallurgy's special steels—combined with one another, or with plain steels or castings, to improve their product and reduce its cost.

Are you taking full advantage of the special steels now available? It will pay you to consult a U·S·S engineer on the best ways to use them. He will be glad to help you.

This symbol represents the highest quality, the finest metallurgical service.

USS

CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*
COLUMBIA STEEL COMPANY, *San Francisco*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*
United States Steel Export Company, New York

UNITED STATES STEEL

A. W. S. Members

H. C. Boardman, Chairman for A. W. S.
J. O. Jackson

Approval of Revised Rules for Field Welding of Storage Tanks

On recommendation of the Committee on Outline of Work the revised report as transmitted to the Executive Committee under date of November 26, 1940, was approved as standard.

Rules to Govern Organization, Functions and Operations of Technical Committees

On recommendation of the Committee on Outline of Work the section on "Approval of Reports" of the above Rules were amended to substitute the following paragraphs for the present first two paragraphs of this section, subject to editorial corrections.

"The work of a Committee shall be presented in the form of a report to the Secretary of the SOCIETY. If the report relates to a new Code, Standard or Specification, the Technical Secretary shall have the report reproduced in mimeograph or proof form and shall submit same to a considerable number of interested people for comments and suggestions. Preferably copy of this report should be sent to all members of the Technical Committees of the SOCIETY. At the same time a copy of the report shall be submitted to members of the Committee on Outline of Work, the Executive Committee and the Board of Directors for comments and suggestions. A definite period shall be provided for the receipt of these suggestions which shall be turned over to the technical committee for study and action."

"After reviewing these suggestions the Committee shall submit a revised report to the Chairman of the Committee on Outline of Work to determine whether this report covers the scope of work intended and whether the report has been properly correlated with the work and the reports of other committees. The Chairman of the Committee on Outline of Work will forward the report with recommendations to the Secretary of the SOCIETY for the action of the Board of Directors. The Chairman of a Committee, in presenting his report, shall furnish a written statement as to the procedure used in correlating his report with the work of interested committees of the AMERICAN WELDING SOCIETY, and of other technical societies or committees. He shall also report the results of letter ballot or other votes of his committee on his report. In case of negative votes, the report should include, if practicable, a statement of reasons for unfavorable votes and the opinion of the Committee as to the validity of the objections raised."

WELDED CRANE TROLLEY

A 45-ton crane trolley of welded construction, built for the Nevada Consolidated Copper Company by Shaw-Box Crane and Hoist Company, is shown in the accompanying picture. The trolley has a main hoist of 45-tons capacity and two

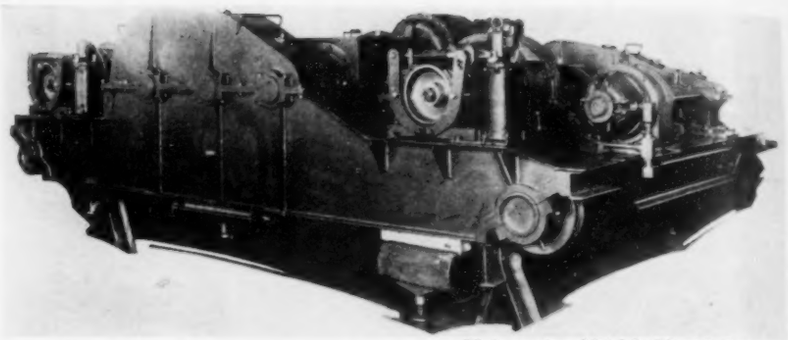


Photo courtesy Metal & Thermit Corporation

auxiliary hoists, each of 20-ton's capacity. The purpose of the two auxiliary hoists is to permit the tipping of the ladle, which the crane handles, from either side.

Welded construction of crane equipment provides important weight savings and increased strength.

YOUTH TAKES ITS PLACE ON THE FRONT LINES OF INDUSTRIAL DEFENSE

With industry geared at top speed to build American defenses, and with workers urgently needed to man the turning wheels, the National Youth Administration has doubled its program to prepare youth for employment in industry. In this program which provides work experience for hundreds of thousands of youth throughout the country, Illinois plays a leading rôle. Here, under the direction of Administrator Mary Stuart Anderson, thirty-three centers are being opened and more than seven thousand young men and women are daily gaining valuable job experience—groundwork for jobs on the nation's assembly lines.

"Industry's increasing employment, particularly in lines engaged in national defense production is decreasing the National Youth Administration rolls weekly," stated Administrator Anderson. "Many employers have come to look to the NYA for youths who have had some basic work experience and who have acquired stable shop habits."

To employers the NYA work experience centers offer workers equipped with responsible attitudes, fundamental job techniques and knowledge of the basic welding methods. Youth who have been taught to protect themselves against burns make safety-conscious workers. Youth who have had NYA welding experience have an excellent foundation for all welding work. These youth have already been initiated into the procedures of modern industry.

Fig. 1—Youth in Welding Dept. at 153 W. Huron St., Chicago, Practicing with Acetylene Torch, Burning Through Metal

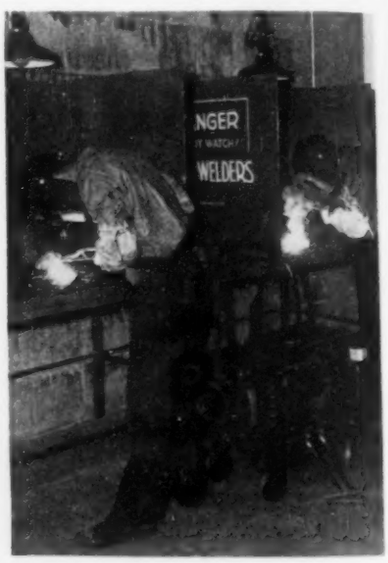


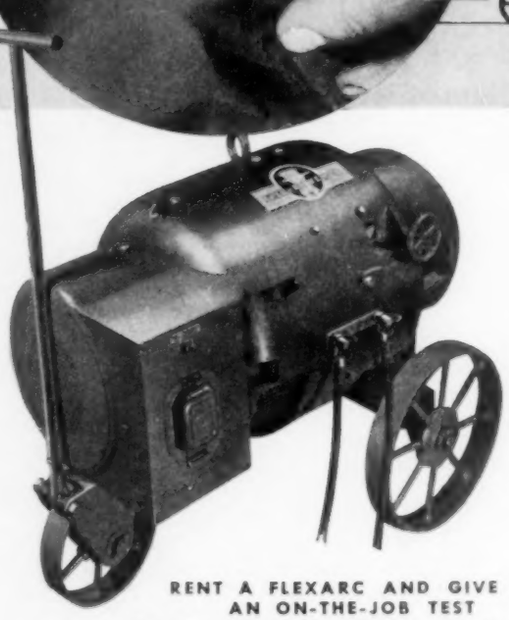
Fig. 2—Youths Gaining Work Experience in Welding Shop

Actual production experience under factory conditions is given to youth not only in Illinois but throughout the Nation. Outside agencies supply the raw materials, or the machinery to be repaired. The finished products and repaired machinery are used by governmental and public agencies whose budget normally would not allow such purchases. Under present production schedules the welding shops are finishing steel cabinets for use in the NYA resident centers. NYA standards demand careful workmanship and each job must pass a rigid inspection.

Explained Administrator Anderson: "In the operation of all centers the NYA

Don't Buy Any Welder Until You Make The *FLEXARC 200-FOOT TEST*

For 200 feet or similar long cable runs — there's no running back to a FlexArc for readjustments.



RENT A FLEXARC AND GIVE IT AN ON-THE-JOB TEST

Here's a real showdown! Rent a FlexArc—see how it stacks up in *your* hands, on *your* job. Easy terms—no obligation to buy. Rental can be applied against purchase price.

Stop in today at any Westinghouse dealer's and make the FLEXARC 200-FOOT TEST. It's a revelation in what you can do with a modern FlexArc Welder.

Just pre-set FlexArc's ONE control—walk off 200 feet, or more, to the job—and weld.

Watch FlexArc give you *automatically* the exact arc you need for any position of the rod—downhand, vertical, overhead, or all in quick succession. Note how current readjustments after warm up are unnecessary—how you never have to chase back to the machine whether you weld for five minutes or five hours.

Consider what these features can mean to you—ability to lay down more metal per hour than you ever did before—no lost time walking back to the machine—better welds because the arc's always right. You'll agree—it pays to make the FLEXARC 200-FOOT TEST before you buy any welder!

WESTINGHOUSE ELECTRIC & MFG. CO.
DEPT. 7-N EAST PITTSBURGH, PA.

J-21067

Westinghouse Flexarc Welders

Fig. 3—John Covich (at Left) and Two Student Welders Putting Their Work Table Together

is striving to help both factors in the employment picture—those who want jobs and those who have jobs to offer. By providing youth with experience in the operation of industrial machinery and in handling tools the way is being made easier for these young people to find places in industry where they will be urgently needed."

The NYA, through mechanical aptitude tests, endeavors to select for basic welding experience those youth who have the education and qualifications necessary for skilled workers. In all cases experience is offered on a step-by-step basis. Only as the youth masters one task is he given another. Although production is organized on assembly lines the youth are rotated through the various jobs to give them all-round experience.

In the welding shops the youth are given the opportunity to work with electric arc, acetylene, gas and spot welding. Working with all kinds of materials on all types of joints the youth become acquainted with the requirements for a perfect weld. They learn to select the filler rod and produce the strongest weld. The youth in electric welding gain experience in regulating the current and voltage. In acetylene welding they gain experience in adjusting the mixture of oxygen and acetylene to obtain the flame which will not burn, or carbonize, the weld. This welding experience is offered under skilled supervision and on modern welding equipment.

Twenty of the NYA centers in Illinois are for out-of-town youth and include living quarters as well as work shops. Unmarried young men and women, between the ages of 17 and 24, inclusive, who are in need of work or experience, are eligible for NYA employment.

O. T. BARNETT JOINS METAL & THERMIT

The Metal & Thermit Corporation, New York, N. Y., announces that Orville T. Barnett has joined its Welding Electrode Department in the capacity of Engineer of Tests.

A graduate of Armour Institute of Technology in chemical engineering, Mr. Barnett has a well-rounded background in the metallurgy of welding. He was formerly associated with the Carnegie-Illinois Steel Corporation in the Metallurgical Control Department, and later, with Black, Sivalls & Bryson, Inc., of Oklahoma City, where he first did research and welding control work, and was later placed in charge of shop inspection. At the Metal & Thermit Corporation, all electrode test work, including manufacturing control testing at both the Jersey City and the East Chicago plants, as well as research work on uses and applications of electrodes will be under his supervision.

O. T. Barnett

D. S. MIX NOW RESPONSIBLE FOR G-E MEDIA AND PUBLISHERS RELATIONS

The assignment of responsibility to D. S. Mix for Media and Publishers Relations, General Electric Publicity Department, Schenectady, has been announced by R. S. Peare, Manager of G-E's Publicity Department and Broadcasting. Under his new duties, Mr. Mix will have responsibility for the work formerly handled by the late F. R. Davis.

A native of New Haven, Conn., Mr. Mix was graduated from the Sheffield Scientific School of Yale University in 1917, joining General Electric immediately thereafter on editorial work in the Publicity Department. The following year he left the company for military service, returning to G-E in 1919 when he was again assigned to editorial work in the Publicity Department. After promotional work in the commercial service section of the same department, Mix was made a contact man with responsibility for directing the advertising and sales promotion activities of a large number of G-E apparatus lines.

In 1929, Mr. Mix was made Copy Chief of the department in addition to his duties as contact man. Since 1932, he has devoted his time to Publicity Department training programs, personnel and special assignments, which he will continue to handle.

D. S. Mix

BRYANT ELECTED PRESIDENT OF THE AUSTIN COMPANY

George A. Bryant of Cleveland, executive Vice-President and general manager of The Austin Company since 1930, has been elected President and general manager of this national engineering and construction organization, succeeding the late W. J. Austin.

Mr. Bryant, a native of Chicago, received his engineering education at the University of Illinois and first became associated with The Austin Company as a field engineer 27 years ago on a building job near Medicine Hat, Alberta, Canada. The superintendent who hired him there in 1913 launched Mr. Bryant on the sequence of jobs which took him to points throughout the eastern half of the United States and Canada in the next three years as field engineer, chief clerk and job superintendent.

In 1916 he was named district superintendent for all Austin operations in New England, and shortly thereafter became manager of the company's Philadelphia office. America's entry into World War I found Mr. Bryant in charge of the company's offices in New York, Philadelphia and Washington, and directing all Austin operations throughout the east. Later, in 1918, he was made general sales manager for the entire country, which responsibility he carried until early this year.

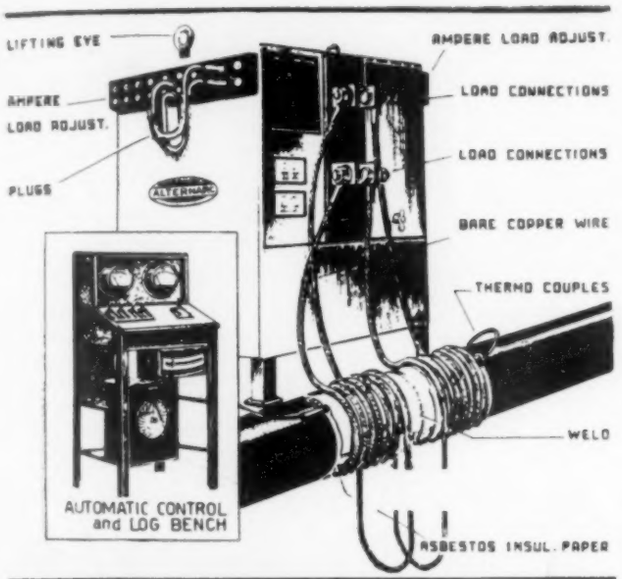
In 1929 he negotiated the contract for a sixty million dollar Russian industrial city and generally supervised the design and erection of this project—one of the largest ever undertaken, embracing complete responsibility for design and construction.

As general manager of the company for the past eleven years, Mr. Bryant has had general charge of the design of buildings, making of contracts, securing of materials and field construction operations. In addition, he has been actively interested in the development, through research, of new structural designs and welded construc-

THE *Simplest Way* OF

PREHEATING-WELDING-NORMALIZING

is the Smith-Dolan Way



THE Smith-Dolan System is the best way of welding high pressure boilers, piping, valves, turbines, penstocks, etc.

With this advanced system you preheat with a.c. hysteresis induction coils wrapped around both sides of the joint about to be welded, then apply a suitable current.

Welding the Smith-Dolan way is simplified because the wrapped preheating coils are not removed. An opening is provided and the welder just deposits the metal.

Stresses and strains are eliminated because the metal has been brought to a proper temperature for preheating and for normalizing the weld. Many plants use this electrical system for heat treating Diesel crankshafts, gears and other live load welding.

Automatic heat control within 1 deg. is feasible with the Smith-Dolan System. It is also safe—low voltage prevents scarring metal. It saves time and money because heating can be done in place. And it heats any size or shape of metal or pipe. Tell us about your welding needs. Write for New Bulletin.

UTILITIES THAT HAVE USED INDUCTION-WELDING HEATING

Long Island Lighting Co.	Glen Cove, L. I., N. Y.
Consolidated Edison Co.	Waterside, N. Y.
Derby Gas & Electric Co.	Derby, Conn.
Central Ohio Power Co.	Springfield, Ohio
Public Service Co., Essex	Newark, N. J.
Public Service	Burlington, N. J.
Public Service Co., Marion	Jersey City, N. J.
Central Power Co. of New York	Oswego, N. Y.
Youngstown Sheet & Tube Co.	Youngstown, Ohio
Philadelphia Electric Co., Schuylkill	Philadelphia, Pa.
Philadelphia Electric Co.	Richmond, Pa.
Philadelphia Electric Co.	Chester, Pa.
Boston Edison Plant	Boston, Mass.
Boston Underground Steam Construction Co.	Boston, Mass.
West Virginia Power	Beech Bottom, W. Va.
American Gas & Electric Co., Twin Branch Station	Mishawaka, Ind.
Narragansett Power	Narragansett, R. I.
Ohio Power Co.	Power, W. Va.
Municipal Power Plant	Chicago, Ill.
South Carolina Power Co.	Parr, S. Carolina
West Penn Power Co.	Steubenville, Ohio
Consumers Power Co.	Comstock, Mich.
Naval Engineering Laboratory	Annapolis, Md.
Carnegie Steel	Rankin, Pa.
Ohio Edison Co., Mad River Station	Springfield, Ohio
Central Illinois Light Co., East Peoria Station	East Peoria, Ill.
Southern Indiana Gas & Electric Co., Ohio River Station	Evansville, Ind.
Duke Power Co., Cliffside Station	Cliffside, N. C.
Pennsylvania Power Co., New Castle Station	West Pittsburgh, Pa.
Youngstown Sheet & Tube Co., Indiana Harbor Works	Indiana Harbor, Ind.
Consumers Power Co., John C. Weadock Sta.	Bay City, Mich.
Indiana & Michigan Electric Co., Twin Branch Plant	Mishawaka, Ind.
The Narragansett Electric Co., Manchester Street Station	Providence, R. I.

LIST OF INDUSTRIAL USERS

United Engineers	Philadelphia, Pa.
M. W. Kellogg	Jersey City, N. J.
Foster-Wheeler	Carteret, N. J.
Babcock & Wilcox	Barberton, Ohio
F. M. Daugherty Co.	Youngstown, Ohio
Grinnell Co.	Providence, R. I.
Hartwell Co., Inc.	Providence, R. I.
General Fire Extinguisher Co.	Warren, Ohio
M. H. Treadwell Co., Inc.	Allentown, Pa.
Midwest Piping & Supply	St. Louis, Mo.
Robert Gordon, Inc.	Chicago, Ill.
Rockbestos Products Corp.	New Haven, Conn.
Naval Engineering Supply Office	Annapolis, Md.
Tidewater Oil Co.	Bayonne, N. J.
Indian Refining Co.	Lawrenceville, Ind.
Texas Oil Co.	New York, N. Y.
Federal Shipbuilding	Kearny, N. J.
Metropolitan Life Ins. Co., Housing Project	Bronx, N. Y.
Walworth Co.	Boston, Mass
W. K. Mitchell Co., Inc.	Philadelphia, Pa.
Pittsburgh Screw & Bolt Corp.	Pittsburgh, Pa.
Blaw-Knox Co.	Pittsburgh, Pa.
Worthington Pump & Machinery Corp.	Harrison, N. J.
E. B. Badger & Sons Co.	Boston, Mass.
Bethlehem Shipbuilding	Fore River, Mass.
Foster-Wheeler	Dansville, N. Y.
Consolidated Gas & Electric	Baltimore, Md.
Stacey Brothers	Cincinnati, Ohio

Electric Arc CUTTING & WELDING CO.

152 Jelliff Ave. **Newark, N. J.**

tion, and in the application of controlled conditions principles in air-conditioned, windowless buildings now of special importance to defense industries.

STELLITE SALES MANAGER

Mr. Robert L. Lerch has been appointed General Sales Manager of Haynes Stellite Company, Unit of Union Carbide and Carbon Corporation, effective December 1st. Mr. Lerch has been associated with Haynes Stellite Company since 1924. During the World War he served in the U. S. Marine Corps. After the war, he returned to Lehigh University from which he was graduated in Chemical Engineering in 1922. He then spent a year and a half in various plant departments of the Bethlehem Steel Company's Lehigh Plant, Bethlehem, Pa. He joined the Haynes Stellite Company as a sales engineer in the New York District, later transferring to the Chicago territory, and next serving as District Sales Manager at Los Angeles and at Houston. Since 1929, he has been Advertising Manager and assistant to the General Sales Manager.

OTTO KESSLER

Mr. Otto Kessler, a Chemical Engineer, for many years with General Chemical Company, has become associated with the enlarged chemical division of the Foote Mineral Company, Philadelphia. He will devote most of his time to production problems of this growing division.

THE WORKING, HEAT-TREATING AND WELDING OF STEEL

By Harry L. Campbell, M.S.

Published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York.

CONTENTS—The Development of Iron Steel Products. The Physical Testing of Steel. The Chemical Composition of Steel. The Classification of Steel. The Physical Constitution of Steel. The Effects of Temperature Changes and Mechanical Working upon Steel. Processes and Equipment for Working Steel. Processes Used in Heat-Treating Steel. Equipment Used in Heat Treating Steel. Alloy Steels and Their Heat Treatments. Processes and Equipment for Welding Steel. The Preservation of Steel. Laboratory Assignments. Index. 230 pages; 6 by 9 inches; 133 figures; $2.25.

This book is for those who need a working knowledge of the making, shaping, treating and testing of steel. It is elementary in that it covers the subject broadly and has deliberately been made easy to read and to understand. At the same time, details are handled authoritatively and competently. Explanations are clear; illustrations and diagrams are numerous. Also, the appended bibliography and lists of reading make immediately available more detailed and extensive studies of the different aspects of metallurgy and heat treatment of steel.

Employment Service Bulletin

POSITIONS VACANT

Wanted. Welding Engineer, graduate metallurgist with experience in fabrication procedure and welding practice. State acceptable salary. Battelle Memorial Institute, Columbus, Ohio.

4 Salesmen Wanted—Distributor of nationally known lines requires experienced welding salesmen for Midwest cities. Salary and commission. Give full particulars of past experience. All applications confidential. Address Machinery & Welder Corporation, 732 S. Spring St. Louis, Mo.

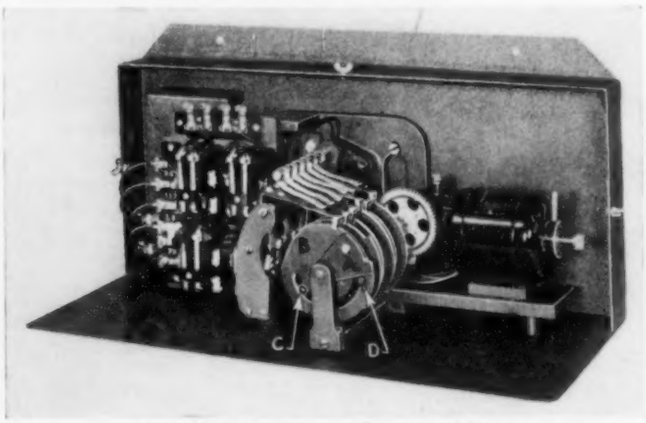
SERVICES AVAILABLE

A-394. Three years' experience in Electric Arc Welding. First training with American Locomotive Co., also employed by Federal Shipbuilding Co. Passed Navy test for regular Navy work; also armor plate test. Would like testing or welding inspectors job.

NATIONAL WELD-TIMERS are ALREADY doing a GRAND JOB on MANY NATIONAL DEFENSE PROJECTS

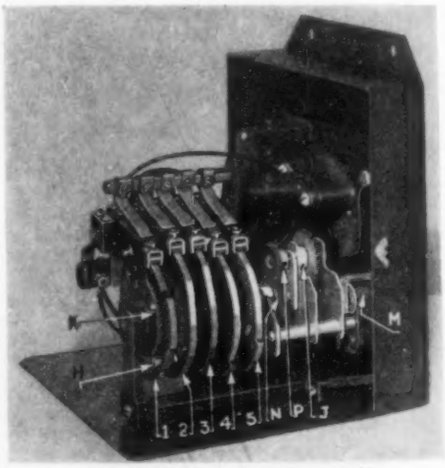
When Hiring Lots of NEW HELP, its Pretty Nice to have Weld Timers that are so SIMPLE TO OPERATE, and EASY TO UNDERSTAND

It makes Little Difference, for Spot Welding ordinary steel plate, 1/4 inch thick, or that very flexible, Stainless Steel, "SKIN" stock, measuring .005" in thickness, there is a National Welding Timer, for EVERY PURPOSE.



No. 1800P Synchronous Timer for Alloys

Have You Written for Your Copy of Bulletin No. 146? Its NEW, and Full of Practical Information.



No. 1750P Timer for General Use

The National Type 1800P Timer at left, is specially adapted to control weld time for special alloys. It synchronizes with the A.C. sine curve, opening or closing on zero. Weld-time, as low as 1/2 cycle, or as much as 30 cycles, is obtainable.

The Type 1750P Timer is used extensively on Gun welders in the automotive body plants. Welding speeds as low as 30 spots per minute, or as high as 360 per minute, are possible.

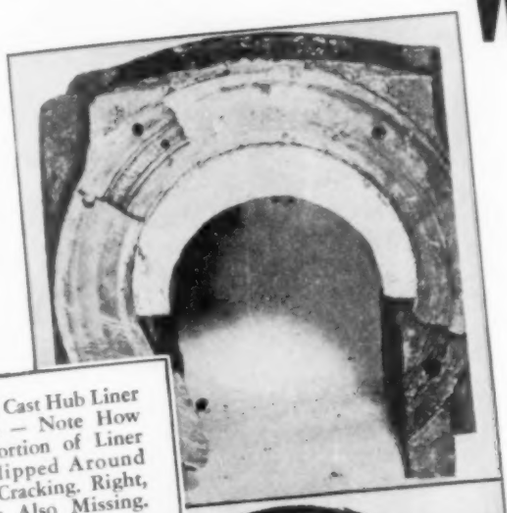
NATIONAL TIME & SIGNAL CORPORATION

600 E. MILWAUKEE AVENUE DETROIT, MICHIGAN

HERCULOY

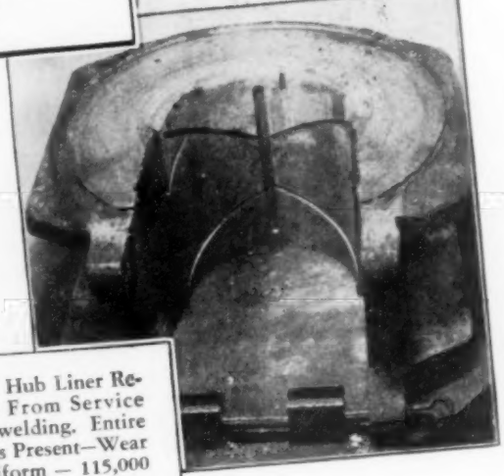
WELDED BEARINGS

...new or re-conditioned ...give *extra* thousands of service mileage



Typical Cast Hub Liner Failure — Note How Left Portion of Liner Has Slipped Around After Cracking. Right, Tip Is Also Missing.

Arc Deposited Hub Liner Before Finish Machining.



Typical Hub Liner Returned From Service for Rewelding. Entire Liner Is Present—Wear Is Uniform — 115,000 Miles Service.

Herculoy—Revere's patented silicon-bronze—has the strength of steel and the corrosion resistance of copper. Among its many industrial successes, the use of HERCULOY FUSION ROD—Herculoy containing lead — for refacing locomotive driving box hub liners has greatly reduced the problem and expense of loose, broken and scored driving box faces. Operation, without repairs, up to 150,000 miles is not uncommon.

Such outstanding performance is due to the introduction of a large quantity of lead in HERCULOY FUSION ROD. This results in greatly increased surface bearing efficiency and simplified machining.

Investigate the use of HERCULOY FUSION ROD for your bearing problems.

We are the owner of Bennett U. S. Patents Nos. 2,166,700 and 2,166,701 which cover, among other things, methods of re-conditioning worn bearings by refacing them with metal from leaded copper base fusion rods by electric arc deposition. In accordance with our policy of promoting industrial use of copper and its alloys, we will give all responsible parties desiring to practise any of the methods covered by these patents licenses to do so on reasonable terms.

If you are interested, kindly communicate with us.

REVERE

COPPER AND BRASS INCORPORATED

Executive Offices: 230 Park Avenue, New York

Sales Offices and Distributors in most of America's major cities

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

LOW COST WELD CONTROLLER

To eliminate the skill required in timing manually timed welds and assure uniformity of welds, a new weld Timer-Contactor to be used with any 15 to 35 kva. manually or mechanically timed spot welder has been announced by Weltronic Corporation, 3098 East Outer Drive, Detroit.

Available for 220, 440 or 550 welding voltages and for 25, 40, 50 or 60 cycles frequency, the new Timer-Contactor unit to be known as Model 108-53 is adjustable over a range of timing of from 2 to 30 cycles. Two control knobs provide for close adjustment to suit the work being welded.

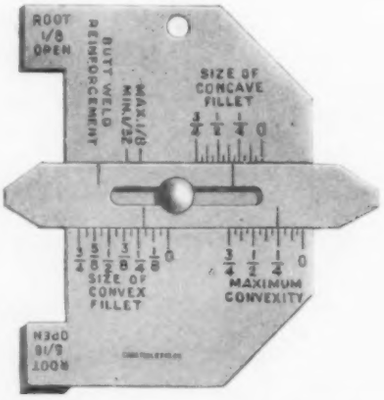
Long life and low maintenance costs are claimed for the new weld "controller." A specially designed high-speed, heavy duty welding contactor is employed. The contacts of both contactor and relay are quickly removable for replacement and

the entire unit can be serviced without specially skilled help. A feature of the new unit—a simplified wiring diagram—permits it to be quickly installed by any electrician.

The entire unit consists of an electronic tube, relay and magnetic contactor enclosed in a compact spring hinge cover case, which measures approximately 11 x 13 x 30 inches, permits mounting either on the welder itself or on a wall or stand nearby.

NEW WELDING GAGE

The Chicago Tool & Engineering Company, 8389 S. Chicago Ave., Chicago, Ill., has just developed a new welding gage that makes it possible to accurately calibrate butt and fillet type welds. The instrument is of convenient pocket size, and easy to operate. A simple adjust-



ment gives accurate reading to determine size of convex fillet welds. To check permissible tolerances of convexity, simply take reading at specified angle. With a similar application of the instrument welder can determine the exact size of concave fillet welds. Butt weld reinforcements can also be checked with surprising accuracy. The instrument is precision-built of chromium plated steel with dimensional readings clearly indicated. It is known as The Precision Welding Gauge, and conforms to specifications of AMERICAN WELDING SOCIETY and sells for $2.00. The manufacturer has prepared illustrated literature describing its many uses.

100 TONS OF STEEL SAVED!

The economies of welding are exemplified in the erection of the new Airlines Terminal Building in New York City which is to be opened this month.

Although the extensive use of welding was not contemplated in the original design, the lowest competitive bid was for welded construction. A big saving was made in the trusses and other heavy units—welded design permitted more efficient utilization of the full section of the members and reduced the material in the connections.

This building was especially impressive because the 1365 tons of structural steel used included two 30-ton trusses each 70 ft. long and a number of heavy plate girders, the largest of which spans 54 ft. An attractive booklet has been issued on this subject by the Air Reduction Co. of New York. Copies may be obtained on request.

USE OF A-C ARC WELDERS

Up until a few years ago, motor graders and blade graders were maintenance rather than construction machines. But now, with diesel power, they are going more and more into the heavy road construction field. Caterpillar motor graders have even proved to be practical in cutting trenches for pipeline and for the heavy job of terracing to prevent erosion of farm lands—in addition to their regular job of heavy ditching, bank sloping and general road construction.

And with the increase in power and strength, it is noticeable that welding is rapidly replacing other forms of fabrication in the building of caterpillar road machinery. In motor grader construction for instance, the circle and drawbar assemblies are among the integral parts where welding is employed. In addition, heavy parts such as motor and blade grader frames, tandem drive housings and road rollers are fabricated by the welding process with 500-ampere a-c welders. The drawbar, which is made of $^{1}/_{2}$ inch steel, is welded with heavy-coated automatic welding heads in straight sections before it is formed. Tractor transmission cases are also constructed entirely with a-c welders.

The Caterpillar Company finds a-c welders of the transformer type to be a definite improvement over d-c welders for

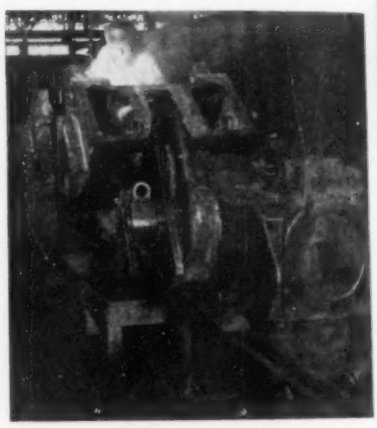


Fig. 1—A Gear Box for a Tractor Being Fabricated in the Caterpillar Company's Plant, Peoria, Ill., with the Aid of a 500-Ampere A-C Arc Welder

Photos courtesy General Electric Company

Fig. 2—Welding a Ring Gear on a Road Grader at the Caterpillar Company's Plant, Peoria, Ill.

this type of work. For instance, a welding speed of 21 inches per minute is obtained with $^{1}/_{4}$ inch electrode, operating at 450 amperes and 40 volts. This speed is considerably better than could be obtained with d-c welders on this work.

ALWAYS CONSIDER
RESISTANCE WELDING

FEDERAL
UNI-PULSE SPOT WELDING

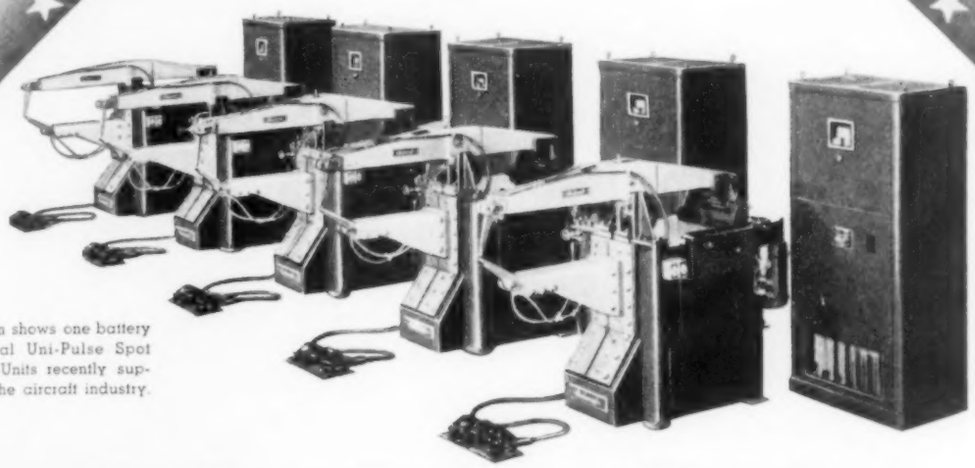


Illustration shows one battery of Federal Uni-Pulse Spot Welding Units recently supplied to the aircraft industry.

The New, Improved Method

FOR SPOT WELDING ALUMINUM AND STAINLESS ALLOYS

★ In perfect step with the national emergency demand for greater efficiency in production of aircraft and other defense materials, Federal provides industry with the "UNI-PULSE" method for spot welding modern alloys. This improved method of welding aluminum and stainless sheet employs electrostatic storage of energy and greatly reduces peak power demands, at the same time providing flexible control of the current wave form. As a result, life of the welding electrode tips is greatly increased and the weld nugget size and shape consistently accomplished. Adoption of the UNI-PULSE welding method, wherever applicable, assures strong, uniform welds and the stepping-up of production quality with the subsequent lowering of fabrication costs.

Federal Resistance Welding Machines are being used in industries both large and small, for simplifying production problems and lowering production costs. The advisory services of The Federal Engineering Division, with 30 years of experience in the design and manufacture of special and standard welding equipment, are available without obligation. Federal is in a position to help you meet defense order demands on time.

In England, made by British Federal Welder & Machine Co Ltd., Dudley, England

Federal MACHINE AND WELDER COMPANY

WARREN, OHIO

SALES OFFICES IN ALL PRINCIPAL CITIES

SECTION ACTIVITIES

CHATTANOOGA

On September 9, 1940, Mr. E. W. P. Smith of The Lincoln Electric Company spoke before the Chattanooga Section on the subject, "Electrical Requirements of the Arc Characteristics of the Welding Generators: Their Effect on Speed and Cost of Welding."

On October 9, 1940, Mr. Wm. D. Halsey of the Hartford Steam Boiler Inspection & Insurance Company spoke on the subject, "Qualification of Welding Procedures and Operators and the Inspection of Welding."

Mr. E. Corbin Chapman, Research & Welding Engineer for the Combustion Engineering Company, spoke at the November 26th meeting of the Section on the subject, "Metallurgical Limitations in Welding."

CINCINNATI

The regular monthly meeting of the Cincinnati Section was held December 11, 1940, in the Engineers' Club. Mr. W. B. Browning of The Linde Air Products Company discussed "The Unionmelt Welding Process." This particular subject held quite a bit of interest for the men in the welding industry, and Mr. Browning spent considerable time after his talk answering questions.

CLEVELAND

A large and enthusiastic attendance—largest in the history of the Cleveland Section—heard Mr. J. Lyell Wilson, Assistant Chief Surveyor of the American Bureau of Shipping, talk on "Welding in the Shipbuilding Industry" on December 11th. Mr. Wilson's talk was illustrated with lantern slides and traced the evolution of ship welding from its earliest application up to the present time. Approximately 90 persons attended the banquet, with 250 on hand for the lecture. Over 40 Great Lakes marine men, including shipbuilders, operators and engineers, were present.

"Facts of Interest" was the general subject of the January 8th meeting. On the program, as guest dinner speaker, was Robert Godley, sports writer for the Cleveland Press. Godley's chief topic was the Cleveland Indian baseball team and its chances of winning the American league pennant and the world's series.

Two other features, both of which were motion pictures, were enthusiastically received. "Wire," a sound picture in technicolor by Bethlehem Steel Company, showed how wire and wire products are made from ore to the finished article. The electric welding arc in action and the deposition of weld metal was shown in a slow-motion picture by the General Electric Company, entitled "The Story of the Arc."

"A Synopsis of Engineering Fundamentals Applied to Welding," the general subject of the 1940–41 educational course, is being enthusiastically received. On January 14th, Professor H. D. Churchill, Case School of Applied Science, spoke on "Terminology and Nomenclature." Two other January meetings on the 21st and 28th, respectively, covered: "The Elements of Metallurgy as Applied to Welding" by Professor G. M. Cover of Case, and "The Determination of the Physical Properties of Materials," a laboratory session by Prof. Churchill.

Now fourth largest, the Cleveland Section has 206 members as compared with 150 a year ago.

COLUMBUS

Mr. F. R. Hensel of P. R. Mallory & Company was the speaker at the January 10th meeting of the Columbus Section. Mr. Hensel's subject was on the "Welding of Stainless Steels."

DETROIT

The fourth meeting of the season held by the Detroit Section on January 3rd was addressed by Mr. R. E. Flood of The Linde Air Products Company, who spoke on the "Use of Oxyacetylene Flame for Flame Hardening." Mr. Flood discussed the use of the oxyacetylene flame for flame hardening steel and iron, covering methods of application and result attained. He also included a description of the newer processes of flame strengthening, covering experimental work which is carried out and applications to which the process may be applied.

MILWAUKEE

The regular monthly meeting of the Milwaukee Section was held on December 20th. An inspection trip through the plant of the Harnischfeger Corporation started promptly at 6:30 P.M. with the first group. Other groups followed.

The welding address was made by Mr. R. W. Clark of the General Electric Company, who spoke on "Procedure Control and Welder Qualifications."

NEW YORK

An outstanding meeting was held on January 14th in the Engineering Societies Building, at which time Mr. Alfred C. Leigh, Naval Architect and Marine Engineer of the Ingalls Shipbuilding Corporation, New York, was the principal speaker. The subject was The First All Welded Cargo Vessel built in accordance with the Maritime Commission's specifications. The presiding officer was Mr. J. L. Wilson, Assistant Chief Surveyor, American Bureau of Shipping. Mr. Leigh's lecture included a short history of the building of the shipyard where the first all-welded cargo vessel was constructed; a description of the vessel's design and items of interest in fabrication and building of the ship, including its trial. Lantern slides illustrated the high points of the talk. This meeting was held in cooperation with the Naval Architects Society. About 450 people attended the meeting.

NORTHWEST

Mr. Elmer E. Isgren, Plant Superintendent of R. G. LeTourneau, Inc., addressed the January 9th meeting of the Northwest Section on "Construction and Fabrication," at the Coffman Memorial Union, University of Minnesota.

PEORIA

The program for 1940–41 is as follows:

February 5th—"The Metallurgy of Arc Welding." Speaker: W. A. Pearl, Developmental Engineer, Whiting Corporation, Harvey, Ill. Moving Picture: "Asbestos."

March 5th—"Welding and Mass Production of Special Products." Speaker: L. M. Keating, Manager, Special Products Division, A. O. Smith Corporation, Milwaukee, Wisc. Moving Picture: "Safety Glass."

April 2nd—"Hard Facing—Its Use and Application." Speaker: Eric Seabloom, Research and Development Engineer, Crane Company, Chicago, Ill. Motion Picture: "Oil Lands of Europe and Africa."

May 7th—(Dinner meeting, place to be announced.) "The Application of Arc Welding to Modern Military Equipment." Speaker: W. F. Schmitt, Welding Technician, Rock Island Arsenal, Rock Island, Ill. Moving Picture: "Alloy Steels, a Story of Their Development."

PUGET SOUND

The Annual Christmas Party was held by the Puget Sound Section on December 18th at the Frye Hotel. The program included cocktails, dinner and music, floor show, raffles—a game of chance—and Santa Claus with gifts for all. The price was $1.00 to members and $1.50 for guests. A good time was had by all.

ROCHESTER

The regular monthly meeting of the Rochester Section was held on January 9th at Todd Union, University of Rochester. Dinner preceded the meeting. Mr. LeRoy L. Wyman, Research Metallurgist, General Electric Company, addressed the meeting on "Heat Effects in Welding."

SOUTH TEXAS

Annual election of officers was held at the December 13th meeting of the South

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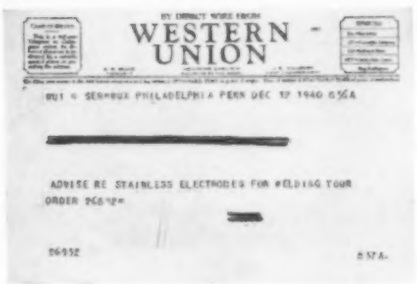
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Texas Section. Mr. W. H. Greer was elected Secretary; Mr. G. W. Woods, Chairman; Mr. J. M. Hughen, Vice-Chairman for the ensuing year.

Mr. William Hudson of the Chicago Bridge and Iron Company gave a most interesting talk on heavy plate-welded fabrication. His talk was accompanied by slides which he used to show the stresses set up in various types of welded joints. Pyralin plates were used in conjunction with polarized light to bring out the points of his lecture. This was most interesting and educational.

The program of entertainment consisted of tap and ballroom dancing. Refreshments were followed by a magical exhibition.

WASHINGTON, D. C.

On December 9, 1940, the third regular meeting of the Washington Section was held jointly with the American Society for Metals at the National Bureau of Standards auditorium. The speaker was Mr. Paul Ffield of the Shipbuilding Division of the Bethlehem Steel Company, Quincy, Mass., whose subject was "Welding of Materials Used in Shipbuilding from the Metallurgist's Viewpoint." The speaker first pointed out how the traditional blacksmith of the shipyard has come to be replaced by the more technical control of the metallurgist by reason of the increasing use of alloy steels in shipbuilding. Slides were shown to illustrate the heavy seas and consequently high alternating stresses that are encountered by ships' structures. Following these, numerous fabricating operations were illustrated and the abuse of galvanized and black steel plates and shapes brought out.

Continual guidance and control by a metallurgist are essential. Fatigue failures were illustrated as being caused by incorrect design of sections in highly stressed parts of the ship. Corrective measures and precautions were discussed.

Deterioration by cavitation and galvanic erosion were illustrated as was also cavitation of the leading overlap in butt joints of the shell. Galvanic corrosion of the shell, shaft struts and propeller, as a result of stray currents, was illustrated. This type of failure can be guarded against by adequate grounding of the shell during construction, a precaution specially necessary when the welding machines are ashore. The session was concluded by an active discussion of corrosion and erosion, and the protective influence of zinc or iron wasters.

In addition to this very interesting and pertinent talk by Mr. Ffield, the Secretary reports that Mr. George Knox, member, has won a prize conferred at the October convention by exactly estimating the strength of an electric-arc-welded specimen of mild steel. Among several thousand estimates Mr. Knox furnished the exact value of 65,420 psi ultimate tensile strength.

YORK-CENTRAL PENNSYLVANIA

Mr. A. N. Kugler, Mechanical Engineer, Applied Eng. Dept., Air Reduction Sales Company, gave a fine talk on new developments and procedures for welding the various alloys with the acetylene process, at the December 18th meeting of this Section. His talk was well illustrated with slides and in spite of the proximity of Christmas, a good crowd enjoyed this lecture and an interesting open forum discussion afterward.

YOUNGSTOWN

The following is the program for the Youngstown Section from February to May inclusive.

February 4th—"The Metallurgy of Welding, by Dr. J. C. Hodge, Vice-President, Wellman Engineering Co.

March 4th—"Machine Flame Cutting and Preparation for Welding," by W. Roy Widdoes, Gen. Mgr., By-Products Steel Corp.

April 1st—"Looking into the Future," by J. W. Meadowcroft, Asst. Works Mgr., E. G. Budd Manufacturing Co.

May 6th—"Flame Machining," by J. G. Magrath, Air Reduction Sales Co. "Flame Cutting," by J. H. Zimmerman, The Linde Air Products Company. "Flame Hardening," by K. F. Schattel, National Cylinder Gas Company. Election of Officers.

LOW BRAZING ALLOYS

A very attractive four-page folder has been issued by Handy & Harman, 82 Fulton Street, New York, describing two low temperaturing brazing alloys Sil-Fos and Easy-Flo. Copies may be obtained on request.

OBITUARY

Fred W. Clifford

Fred W. Clifford, founder of the company now operating under the name Victor Equipment Company and one of the early pioneers of the welding industry, passed away Monday night, December 30th, at his home, 75 Ashbury Terrace, San Francisco.

Fred Clifford was born in Concord, New Hampshire in 1866, and was the founder and owner of the first American electrolytic oxygen plant which he built at Niagara Falls, with headquarters at Buffalo, N. Y.

Having moved to California some thirty odd years ago, he founded in San Francisco in 1910, the Great Western Welding & Cutting Co. This company became the largest welding shop of its kind on the West Coast and originated the line of Victor welding and cutting apparatus. As the demand for these equipments grew the company's name was changed to Victor Oxy-Acetylene Equipment Company, and all efforts became directed toward the production and sale of this apparatus. With the increasing demand the company's original and small plant became inadequate but the new one was built in the same block on Folsom Street. In 1928 the company's name was once again changed to Victor Welding Equipment Company and a year later upon further expansion the present name of Victor Equipment Company was adopted.

Fred Clifford was Secretary-Treasurer of these companies until his retirement the latter part of 1928.

With unbounded enthusiasm he foresaw the potential growth of the welding industry and even though his early efforts both in the East and on the West Coast were fraught with the constant hazards and repeated disappointments inherent in pioneering days his undaunted confidence and his irrespressible courage and enthusiasm carried him over every hurdle.

He was a member of Doric Lodge 216 F. & A. M. and San Francisco Scottish Rite Body, also a member of the Islam Temple Shrine. He belonged to the San Francisco Commercial Club.

He is survived by his wife, Mabel Clifford.

REVERE AWARD

The Revere Award is something new in this country. Nine cash prizes totaling $10,000 will be given for the suggestions, submitted by American workmen in the metal industry, that will do most to accelerate our country's industrial defense program. Revere Copper and Brass Incorporated has donated these prizes and offers this plan as a patriotic contribution to American security.

In the past, the skill of the man at the bench played a great part in making the United States the world's leading industrial nation. Revere sincerely hopes that this earnest effort will make far more available for defense use at this time the resourcefulness and ingenuity of America's workmen.

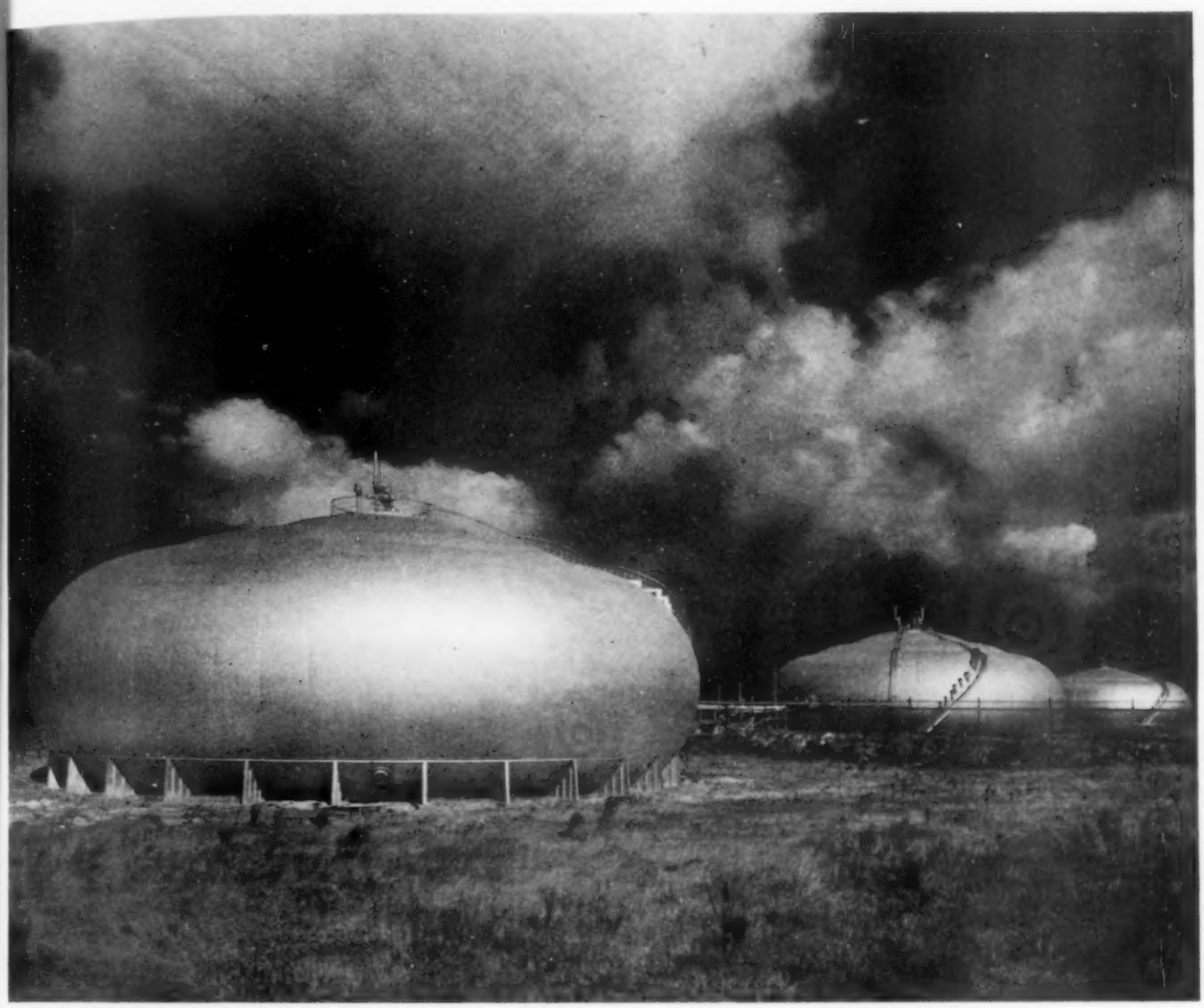
A booklet containing detailed information about the Revere Award will be sent on request by writing to the Revere Copper & Brass, Inc., 230 Park Ave., New York, N. Y.

A.S.T.M. MEETINGS

1941 Spring Meeting, March 4th and 5th, The Mayflower, Washington, D. C.

A.S.T.M. Committee Week—March 3rd to 7th, inclusive, The Mayflower, Washington, D. C.

1941 (Forty-fourth) Annual Meeting and Exhibit of Testing Apparatus and Related Equipment, June 23rd to 27th, inclusive, Palmer House, Chicago, Ill.



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These Hortonspheroids, used to store volatile natural gasoline under pressure, are smooth and sleek because their shells are butt-welded. The seams are almost invisible a short distance away, so that the vessels appear to be made in one piece.

Welding has changed the appearance of many steel structures, but preliminary preparation for welding is important too. We have developed the work of forming steel so that the plates follow a true curve in any direction. Our patented fitting-up system insures a smooth butt-joint while welding is going on.

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Cleveland	2282 Rockefeller Bldg.	Houston	2919 Main Street	San Francisco	1097 Rialto Bldg.
Dallas	1489 Liberty Bank Bldg.	Detroit	1556 Lafayette Bldg.	Los Angeles	1455 Wm. Fox Bldg.

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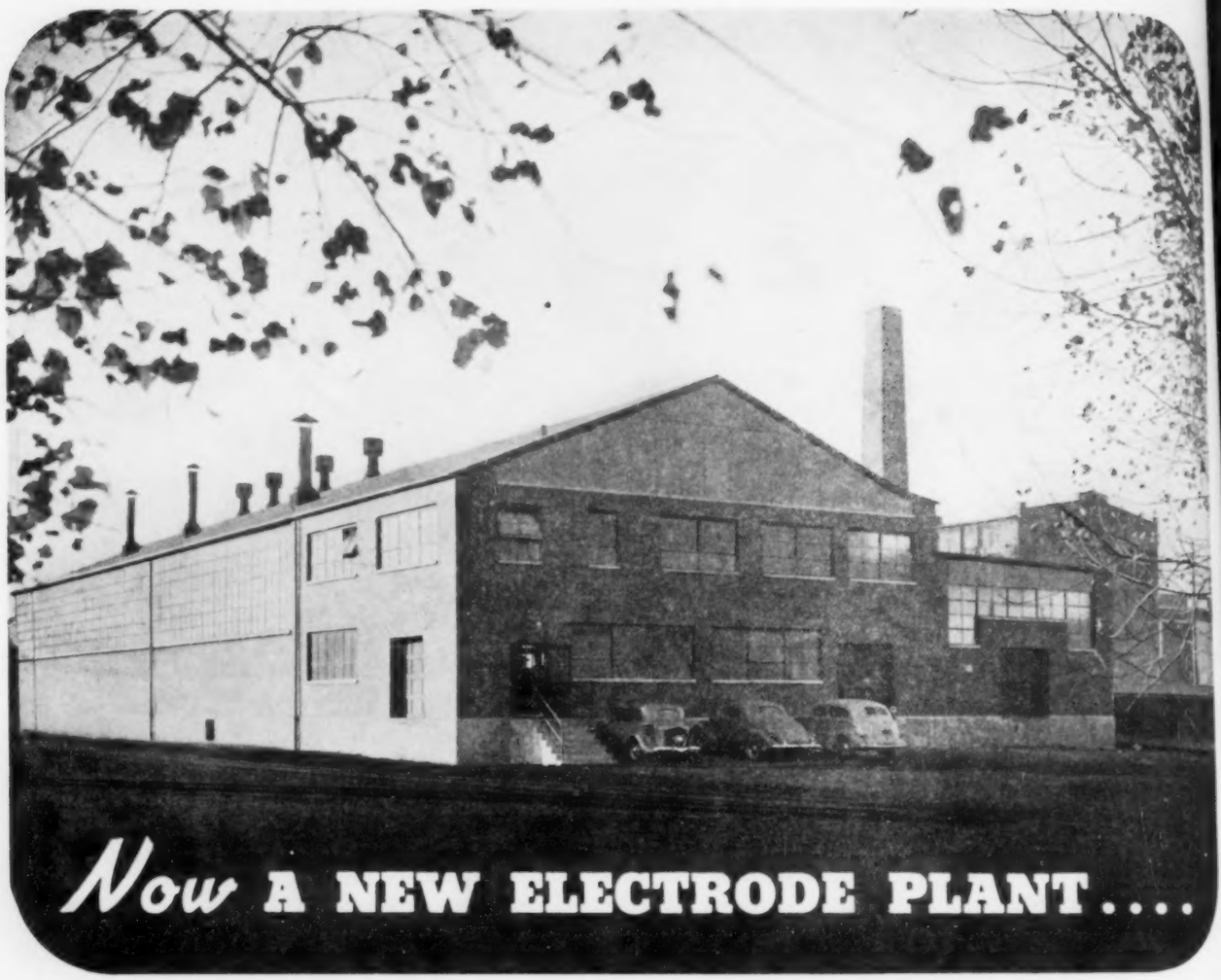

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Designed and built expressly for the manufacture of arc welding electrodes, this up-to-the-minute factory is equipped with the most modern facilities available for the efficient production of electrodes of high quality and absolute uniformity. Its operation supplements that of the original Murex plant at Jersey City, N. J., and more than doubles the output of Murex.

Located close to sources of raw materials and in the heart of the busy mid-western industrial area, the new plant with the additional production capacity it provides, assures better service and more prompt deliveries to Murex customers throughout the country.

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